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Photo by the Gillmans Service

Sending sheep through a "dipping tank" before shearing
THE WOOL PRODUCT DWINDLING [See page 392]

Ocean Cables and Wireless*

As Weapons of Commerce

In the reconstruction period following the war the nations possessing the best systems of rapid electrical communication with distant possessions or distant markets will have a very great advantage in their commerce and national development. On the other hand to boycott a nation by curtailing its electrical communications would mean placing an almost insurmountable obstacle in the way of its foreign trade. For instance, present day foreign exchange is dependent very largely on the use of the cable. It is through cable quotations that the prices of commodities on the world's markets are settled. Whereas a despatch sent by regular mail, from the United States or Europe to South America requires normally the best part of twenty days, a cable or wireless message requires but twenty minutes for delivery.

If the reconstruction after the war is along clearly cut national or imperial lines the possession of strategic stations for cables or wireless apparatus will rank in importance with the possession of coaling stations. As in the case of coaling stations, the foremost nation today in the ownership of these islands and ports serving as cable or wireless relay points is England. English capital also controls the majority of the great international trunk lines of cable, having built up a world-wide system during the sixty or more years since the first international submarine cable was laid. On the other hand wireless telegraphy is of such recent development that world systems have not yet been completed. England, however, just before the war had actually under way a plan for an imperial wireless scheme to link up the different parts of the British Empire. Germany early recognized the importance of a cable system independent of British control to unite the scattered German colonies and the mother country, and after twenty years of effort had at the beginning of the war almost succeeded in creating such a system. By the conquest of the German colonies England has now undone this work. France was also striving during the years before the war to connect her colonies with herself by means of French cables, but several gaps still remain in the French system. The United States ranked second only to England in the possession of international cables.

The longest continuous stretch of cable now working, that is, without relay, is 3,458 nautical miles—that from Vancouver to Fanning Island in the Pacific, and the average distance without relay is much less than this. It is evident, therefore, that on the long trans-oceanic cables such as those across the Pacific, islands must be found for relay stations. This explains the rivalry of certain of the European nations for the possession of small, solitary islets, scarcely more than mere rocks; and useless except for just such a purpose as this. This was the reason for Germany's acquisition of the Caroline and Marianne islands and later of one of the Samoa group, at the time of our war with Spain. Similarly England is to be found in possession of conveniently placed islands all over the world.

The British cable system is in large part under the control, directly or indirectly, of one company, the Eastern Telegraph Company, whose lines together with those of controlled companies and the British government-owned lines, comprise the main trunks of the British system. The Eastern has two main lines from England to the Far East, one via St. Vincent on the Cape Verde Islands, which belong to Portugal, and thence via Ascension and St. Helena to Cape Town, South Africa. The line from Cape Town to Durban is overland. From Durban one line crosses the Indian Ocean via Rodriguez and Cocos Islands to Perth, Western Australia, and thence to Adelaide, Melbourne, and Sydney and across to New Zealand. The stretch from Rodriguez to Cocos is 2,200 miles with no intervening islands. Another line from Durban goes northward via Mozambique and Zanzibar to Aden, and thence Eastward to Bombay, overland to Madras, and under water to Penang, Singapore, Hongkong, and the principle Chinese and Japanese ports. The stretch from Cape Town to Durban, South Africa, which is overland, sometimes does not work properly, in which case messages are sent via the second great trunk line via Gibraltar and the Mediterranean. Stations on this route are located at Malta, Suez and Aden. From Aden the route is the same as that on messages coming North from Durban, previously described.

Just before the war the laying of an additional line was completed, from Aden to Colombo, Ceylon and thence to Penang, on the Malay Peninsula. It will be noted in all of these routes how the possession by Great Britain of strategic ports and islands enables the cable lines to avoid all foreign territory, with the exception of Portuguese.

A third route to the Far East, in which British capital has a controlling interest, is that via the Great Northern Telegraph Company, which crosses Scandinavia into Russia and follows more or less the route of the Siberian Railway to Vladivostok, and thence southward to Shanghai. In view of the present Russian situation the future of this cable is problematical.

As the Eastern Telegraph Company and its affiliated concern, the Eastern Extension, Australasia and China Telegraph Company had practically a monopoly of cable traffic to the British possessions in the Far East, the British government undertook some years ago the creation of a government-owned line to reach the East via Canada and the Pacific Ocean. The trans-continental line from Montreal to Vancouver was secured, and a cable laid from Bamfield Creek, Vancouver, via Fanning, the Fiji, and Norfolk Islands to Brisbane, Australia. The stretch from Bamfield Creek to Fanning, which as was stated above is the longest in the world, was made necessary owing to the fact that the only intervening land, the Hawaiian Islands, belongs to the United States.

British Pacific cable is under the control of the Pacific Cable Board, a government agency. Although from Montreal on this route is all-British, it has so far failed to fulfil its purpose of providing an all-British route from England to Australia, as there were until recently no British-controlled cables crossing the Atlantic to Canada. The Dominions Royal Commission has recently strongly advocated the completion of the system through the acquisition of a line from England to Montreal by the government, and it is not impossible that the recently acquired British Government trans-Atlantic cable will accomplish this. It is felt that the acquisition of an existing cable is preferable to the laying of a new one, as the present cables are more than sufficient to carry the traffic offered in normal times.

There are thirteen cables reaching Great Britain directly from North America, eight of which are controlled by the Western Union Telegraph Company, being leased for long terms from two British companies, the Anglo-American and the Direct United States Telegraph Companies, and five which are controlled by the Commercial Cable Company. Both the Western Union and the Commercial are essentially American companies.

On the English end landing licenses renewable at intervals are required by the government, which in this way is able to exert a measure of control over the companies. This control practically amounts to little. Both companies have their own offices in the principal provincial cities of the British Isles, in addition to which the British Post Office, which operates the government internal telegraphs, is bound by an agreement expiring in 1920 to turn over to one of the companies, the Anglo-American, all unrouted messages received by it destined for North America. This agreement of course precludes the commercial operation of a British government trans-Atlantic cable before 1920. The British Post Office divided its Australian trade equally between the Western Union and the Commercial, and a similar division is made up by the Pacific Cable Board on Eastbound messages.

In addition to the great British cable lines running to the Far East, the Eastern Telegraph Company controls, through its affiliated company the Western Telegraph Company, lines across the South Atlantic to Brazil and Argentina. One route is via the Azores and St. Vincent to Pernambuco, a second is via Lisbon and Madeira, and a third branches off from the South African line at Ascension Island and goes direct to Buenos Aires. The chief Brazilian ports are reached by coastwise cables south from Pernambuco. Until recently the Western Telegraph Company, had monopoly rights guaranteed by the Brazilian government over all oceanic cables landing in Brazil. For this reason messages for Brazilian points from the United States had to go to the Azores or to Europe, and thence back across the Atlantic over British wires.

The British world system, whose main lines connecting England with her overseas possessions and markets have now been described, is at the present day quite complete, with the exception of the North Atlantic crossing, and future laying is likely to consist largely of connecting up existing stations in new ways, or of paralleling present cables. The most ambitious scheme suggested is one for a South Pacific cable, from New Zealand to the Chilean coast, which would be difficult to operate on account of the scarcity of intervening islands.

In the laying of any future cables after the war England possesses a great advantage, if she chooses to use it, in the fact that she is the only nation able to construct great lengths of submarine cable. Germany, which before the war also manufactured cable, is dependent on Allied nations for supplies of gutta percha, jute and other raw materials essential to cable construction. England's monopoly of this industry depends on the fact that cable construction requires especially constructed and expensive plant, together with a force of experts and skilled labor, which requires a long period for development.

The United States, although not manufacturing its own cable, possesses today an extensive system of cable lines which reaches its possessions and naval stations, as well as most of the Central and South American countries, and includes the North Atlantic lines to Great Britain. With the exception of the United States Government cables to Alaska and in the Philippines the American cables are privately owned and not subject to direct government control.

In view of our important trade relations with Latin America the possession of an American cable to all the countries South of us is of importance. This accomplishment bids fair to be achieved in the near future through the efforts of the Central and South American Telegraph Company with its affiliate the Mexican Telegraph Company. The Mexican and Central American lines of this company leave the United States at Galveston, and reach the Pacific ports of Guatemala, El Salvador, Nicaragua and Costa Rica after crossing the isthmus of Tehuantepec. The main South American lines go from New York direct to Colon with a relay on the United States naval reservation at Guantanamo, Cuba. From Panama the lines run South to Valparaiso with three relays, at Santa Elena, Ecuador; Chorillos, Peru, and Iquique, Chile. The Central and South American Company also owns the overland line to Buenos Aires, a part of which in crossing the Andes is buried deeply enough to obviate trouble from storms or slides.

The story of the efforts of this company to get into Brazil against the monopoly of the British Western Telegraph Company is well known. After half a century of negotiation permission was finally obtained early in 1917 by a decision of the Brazilian Supreme Court, whereby the American concern is to lay two lines from Buenos Aires to Rio de Janeiro and Santos respectively. The laying of these lines has not yet been started, however, owing to the fact that it is impossible to obtain the cable from England. At present the Central and South American has an arrangement with certain of the private native overland lines by which messages can be sent through to Brazil. The result of the somewhat roundabout routes necessary for a message to reach Brazil has been that rates have always been considerably higher than to Argentina, although geographically Brazil is the nearer the United States. With the linking up of Brazil with the rest of the American system all of the largest cities of Latin America will be connected with this country by American cables. Interior points can be reached via the national telegraph systems, which are generally operated by the governments of the respective countries.

Another great American oceanic cable is the Pacific cable, which is part of the Commercial system, and was built to connect with our Eastern possessions. Leaving San Francisco this cable is relayed at Honolulu, Midway and Guam Islands, and reaches Manila where it meets with a branch of the Eastern Telegraph Company coming from Hongkong. Branches also reach Shanghai and Japan. The Pacific cable is wholly on American territory, each of the three island relay stations belonging to the United States. The case of Midway Island is typical as showing how solitary island groups, scarcely more than coral reefs, may be of much strategic importance. Midway was stumbled upon by American navigators in 1867 and taken possession of in the name of the United States, long before a Pacific cable was planned. The principal island of the Midway group, upon which the cable station is now located, is only a mile and a half long and three quarters of a mile wide. The group is 1,332 miles from any other islands. The only inhabitants are the staff of the cable office. When the office was constructed the island consisted entirely of white coral sand, being absolutely without vegetation. Shiploads of earth have now been carried there, grass and trees planted, and birds and cattle established on the island.

One of Germany's schemes before the war for creating a cable route to her Malay possessions free of British control contemplated utilizing the American Pacific cable as a neutral line. Germany had an agreement with Holland whereby the two nations developed a joint system connecting the various German and Dutch islands in the East Indies. The starting point was the

*Courtesy of *The Americas*.

German island of Yap in the Carolines, which was connected with Guam and with Shanghai. Southward from Yap a line reached Borneo and Celebes and thence to Java and Sumatra. Germany's New Guinea and China colonies were also joined to this system. These possessions could be reached from Germany via two German trans-Atlantic cables and the American system. All of the German plans for an imperial cable system were fostered by the government by means of large subsidies at first, which were decreased as the traffic grew. The cables were owned, however, by four large private companies, whose holdings just before the war totaled over 23,000 miles. Almost all of this cable was made in Germany and laid by German vessels.

The two German trans-Atlantic cables left Germany from Emden and were relayed at the Azores, where the Portuguese government had granted permission for a station, and thus reached New York. At the opening of the war the British cut these cables between the Azores and Emden to prevent messages reaching Germany.

Germany's African possessions were included in the imperial scheme. A line was laid from Borkum to Vigo, Spain, but an application to the Spanish government to permit extension of this line to the Canary Islands was refused. Another line was laid, however, directly from Germany to Teneriffe in the Canaries and thence to Monrovia in the independent African republic of Liberia. A year before the war began the Germans extended this line from Monrovia to Lomé in the German colony of Togoland and thence to Duala in the German Cameroons. Agreements were also made whereby in 1919 Germany was to possess a line from Duala to Swakopmund, German South-West Africa. Thus all the German possessions in Africa except German East Africa would have been joined to the mother country.

In connection with German commercial plans in South America a cable was laid in 1911 from Monrovia to Pernambuco, Brazil, and a controlling interest was bought in an Argentine cable from Buenos Aires and Montevideo to Colonia. It remained only to connect Colonia with Pernambuco to complete an all-German route from Germany to Buenos Aires. The war, however, cut short the plans at this point.

Besides England, the United States and Germany, the only nation that has so far essayed the creation of a trans-atlantic cable system is France. The French colonies are extensive, but the cable system is as yet incomplete. The French government owns and operates its cables. There are two trans-Atlantic lines from the United States to Brest, France, a French line in the West Indies, and a line from Brest to Dakar, French Senegal, on the African coast, and southward to the other French colonies as far as the Congo. A branch from Dakar crosses to Pernambuco, Brazil. In the Far East France is entirely dependent on foreign cables.

Since the war began no important new cable lines have been laid. Much energy is being devoted to improving the usefulness of existing lines, principally in the way of automatic relays. The advantages of the automatic over the manual relay are principally increased speed and accuracy. The greater the speed at which messages are sent, of course, the greater the capacity of the cable. On land telegraph lines the capacity is increased greatly by the multiplex systems, whereby many messages may be sent over a wire at the same time. These systems have not been found practicable for submarine cables excepting in the case of the duplex system, which has been in use for many years. This system utilizes dummy circuits, whereby one message may be sent in each direction over a wire at the same time. The speed of a cable depends on the length between relays, being only one quarter as great if the distance is doubled, for a cable of a given size. The maximum capacity of a cable is about 27,000 words a day, or 10,000,000 words a year. Of the automatic relay devices, Brown's drum relay, Muirhead's gold wire, and Heurtley's magnifier are the best known. Heurtley's system, which is used by the Commercial, the Eastern, and the French Telegraph Companies, depends upon the difference in the electrical resistance of a fine platinum wire when hot and when cold. The electrical impulses coming over a long line of cable are of course extremely weak, so the frame holding the platinum wires and a coil is very nicely balanced between two magnets. The feeble current causes the frame to turn slightly to one side or the other in accordance with the dots and dashes of the code. A slight turn one way brings a platinum wire into a blast of hot air, and a turn the other way into a blast of cold. The current passing through the platinum wires is thus altered, and works to relay the message on through the main cable. Recently messages have been successfully relayed without human hands from New York to Valparaiso and even Buenos Aires, a distance of 7,000 miles.

The somewhat complicated nature of the Heurtley automatic relay, and the need of maintaining hot and cold blasts, has led to considerable experimentation with a very simple form of instrument. This is the selenium relay, and utilizes the rare metal selenium, which varies its electrical resistance strongly according to whether it is in light or darkness. In this instrument a mirror with a coil is delicately suspended between two magnets, and so arranged that it reflects a beam of light from a nearby lamp between two bars of selenium, which are connected with the relay circuit. As impulses come in and pass through the coil the mirror swings slightly and the beam of light strikes one or the other of the selenium bars, thus permitting a current to pass.

Methods of gaining speed at the sending and receiving ends of a cable line are by means of automatic transmitters and the siphon recorder. Messages to be sent are punched out in dots and dashes on a tape, by a perforating machine, which is then run through a transmitter which sends the matter over the wire at higher speed than could be done by hand. The siphon recorder receives the message and records it on a tape for deciphering by the operator.

The recent development of wireless telegraphy has already begun to affect the cable situation in some degree, but the years immediately following the war bid fair to be those in which it will be given its real chance at competition in international communication. Since the war began the various wireless stations in the belligerent countries have been taken over by the governments, and hence the commercial use of wireless has ceased. Preparations are already being made, however, for the period after the war. The erection even of a high power station, capable of sending 5,000 to 7,000 miles, means a capital investment of less than the construction of a cable of that length, while the cost of operation and maintenance is correspondingly less. From a strategic point of view the wireless possesses the advantages of not requiring as frequent relay stations as the cable, nor of being open to disablement through cutting of intermediate lines.

England, just before the war, had started on the building up of an imperial system, the chief stations of which were to be Oxford, England; Cairo, Egypt; Poona, India; Singapore; Pretoria, South Africa and Nairobi, British East Africa. These stations, when constructed, were expected to communicate with each other, forming relay lines to the Far East and South Africa. The largest English station at present is that at Carnarvon, Wales, which communicates directly with the United States.

The United States has been developing its wireless rapidly since the war began. The stations at Belmar, Radio, Va., New Brunswick, Tuckerton, Chatham and Marion on the East coast, together with the Sayville plant, now operated by the U. S. Navy, communicate with Europe and Panama, as well as with the stations at San Diego, San Francisco and elsewhere on the Pacific Coast. The Philippines are reached by relay at Pearl Harbor, Hawaii, to Cavite, near Manila. The Marconi Company's station at Marshall and Bolinas, California, receives direct from Funibashi, Japan, and also by relay at the great duplex station at Koko Head and Kahuku,, Hawaii. The receiving and sending antennae of the latter stations are twenty-five miles apart, with balancing towers intervening, to prevent interference.

A plan is under way for the construction of an American wireless system to link up Latin America with the United States. A company which has recently been organized will erect a station at Buenos Aires which will communicate directly with New York. Other stations are planned by this company at Guayaquil, Lima, Iquique, La Paz, Antofagasta, Valparaiso, Montevideo, Ascuncion, Bahia, Pernambuco, Para and Rio de Janeiro.

The Germans, starting from their central station at Nauen, had before the war several communicating stations like the one at Sayville, on foreign territory, as well as others, in part secret, in their colonies. An attempt was made even after the war started, to get permission to erect a station in Argentina. Doubtless after the war the Germans will continue their efforts to build up a wireless system, although they have now lost their colonies.

Among other wireless should be mentioned the Eiffel Tower in Paris, and Stavanger, Norway, both of which communicate with the United States on occasion. Although it is hardly more than a decade since wireless first became of commercial value, the world today is dotted by literally hundreds of smaller stations, in addition to the larger ones used for long-distance service. It is undoubtedly true that during the past three years remarkable progress has been made in the direction of secrecy, high speed working and reliability under all conditions, the results of which development will greatly benefit the interchange of commercial communication.

The commercial use of wireless has another great field open to it, in which the cable cannot compete. This is in communicating with ships at sea, a field in which far-reaching developments are to be expected after the war, and in which the peculiar advantages of wireless will make themselves felt to a large degree. The communication of land stations with ships, and of ships with each other, give opportunities for the building up of a new class of operations in international commerce. By wireless ships may be diverted from one route to another. They may set sail from port with no orders as to their ultimate destination, being merely directed to proceed in a certain direction across the ocean, and await wireless messages directing them to this country or that. For instance, a ship may load with wheat, or hides, or wool, at Buenos Aires, and depart with orders simply to proceed in a northeasterly direction. The owners of the cargo meanwhile are watching the quotations on this commodity in the markets of the United States and Europe. After the lapse of a few days conditions in the New York market may be such as to bring the greatest chance of profit. A wireless message is sent to the vessel directing it to take a course toward New York. A week later, however, while the vessel is still in the tropics, the New York market may undergo a sudden slump, whereupon another wireless order is sent to switch the ship to London.

An even greater development of this system of control consists of actually affecting markets by means of wireless messages to ships carrying valuable cargoes. A given commodity in the New York market, for example, may undergo a considerable rise in price owing to lack of visible supplies on hand or approaching that city. Immediately wireless messages may be sent to perhaps a dozen vessels all over the world sailing toward London or some other market, and these ships diverted toward New York. The effect of this might be to reduce prices in the latter market so that later messages would be sent out changing the ships back to their former routes. By merely altering the course for a short while of vessels in the Pacific or South Atlantic oceans, users of wireless might thus affect the prices on the world's exchanges. One of the results of this wireless control of the world's commodities will be a closer adjustment of prices between markets and closer international ties.

Responsibility of the Dentist

THE dentist is responsible for the discovery of certain hidden causes of disease and their eradication. Well-informed people realize that the dentist has this very new and important responsibility. With this understanding comes the realization that the dentist is depending upon the physician and the physician upon the dentist for the accomplishment of this result, and for the conservation of their patients' health and lives.

These hidden causes of disease are called focal infection. And focal infection is the technical name for those little areas of disease which are the source from which germs are carried to other places to cause disease or death of organs or tissues or poison the system generally. These focal infections hold an important place in medicine.

Where there is a polluted well, the pollution or infection trickles through the crevices of this polluted well. It is disseminated throughout the community to spread disease and death. These focal infections, these wells of pollution, these little disease producing spots, have their poison and disease germs distributed throughout the system. Where there is one of these areas of pollution on the end of a tooth, for example, this pollution, this infection, is distributed through the entire body by means of the arteries, the veins and other means of communication. These little focal infections, these little abscesses, within the last four or five years have come to be looked upon as one of the most frequent sources from which the rest of the body is poisoned. They are little painless cesspools, of which we are not conscious, and which neither the dentist nor the physician can see except when the X-ray is used. These abscesses are not necessarily small, for some times they are as large as an egg. The X-ray picture then shows a little shadow around the ends of some teeth or in the jaw bone. These little shadows are the evidence that these hidden wells of pollution have destroyed the bone and are poisoning the system.

Until a few years ago the dentist looked upon teeth as teeth. You looked upon teeth as teeth, and so did surgeons and physicians. The teeth had no particular significance or relation to the rest of the human organism, neither influencing health nor causing disease. But within the last few years a new conscience regarding teeth has come to us, a new conception of teeth. We realize that the teeth are a particular and peculiar source of trouble when they are diseased, and a great influence in preserving health when they are sound. So physicians, in seeking the causes of many diseases which they did not find, have come to the conclusion that diseased teeth are a great menace in causing certain diseases, and sound, disease-free teeth a great help in curing them. —From a lecture by A. M. NODINE, D.D.S., before the Golden Jubilee Meeting, Tennessee State Dental Society, 1917, reported in *The Dental Summary*.

The Deeps of the Pacific

A Wonderful Region of Mystery; Some of Its Inhabitants and Characteristics

By Vaughan McCaughey

THE deep seas were absolutely unknown to mankind for thousands of years. Primitive man's imagination pictured the marine abysses in all manner of grotesque and fearful ways. Sailor folk are notoriously superstitious and imaginative. Until the present age of science there was little accurate information concerning the ocean floor.

During the past few decades, however, deep sea explorations have created a working knowledge of the ocean bottom. They have revealed the strange and wonderful creatures and life-conditions that characterize the abyssal plains. Sir John Murray's work and writings, for example, have made intelligible the scattered technical records of investigators in many countries.

During ten years' scientific work in the Hawaiian Islands the writer has been much interested in the vast oceanic depressions which surround on every side this remote and isolated mid-Pacific archipelago. The present paper, insofar as is known to the author, is the first concise and semi-technical account of the abyssal Pacific, greatest and deepest of oceans.

Most of the earth's surface is covered by deep oceanic waters. Water more than one mile deep (6,000 ft.) covers 85 per cent of the world's ocean beds. These marine depressions, from one to six miles deep, cover an area nearly twice as large as the total land area of the planet. The waters which lie between three and four miles cover an area of nine million square miles. This is greater than the total area of North America. The mysterious depths which lie below 24,000 ft. (nearly 5 miles) have a combined area of 216,000 square miles which is nearly 1.5 times the area of California.

The total number of deep sea soundings, including the records of all explorers, is about 6,000. About 2,500 of these have been made in the Pacific, 2,500 in the Atlantic, and 1,000 in the Indian Ocean.

The deepest sounding on record is 31,614 ft. or *six miles*. This was made in the Challenger Deep, in the North Pacific, near Guam, in 1900, by the United States cable-survey ship *Nero*. The second deepest sounding is 30,930 ft. in the Aldrich Deep in the South Pacific. The Pacific exceeds the highest known elevation above sea level, which is Mount Everest, in the Himalayas, 29,002 ft. in height. The island of Hawaii, largest of the Hawaiian group, is a titanic partly-submerged mountain, rising 30,000 ft. or more from the Pacific floor.

The vertical distance between the earth's greatest height and the ocean's greatest depth is about 11.5 miles. However, as Murray observes, "this range is very small when we remember that the diameter of the earth is nearly 8,000 miles; in fact, on a six-foot globe a mere scratch one-tenth of an inch deep would represent the extreme variation in the irregularities of the earth's surface."

Murray also states that it is unlikely that the ocean's maximum depth is yet known. He suggests the improbability of soundings greater than six miles. The mean depth of the ocean is about 12,000 ft. (over 2 miles). The mean continental elevation above sea-level is only 2,300 ft. (not half a mile). Viewed from the ocean floor the continental masses would appear as plateaus rising to heights of 14,000 ft. The island of Hawaii at present rises to this elevation above sea-level.

The Pacific floor is covered by vaster depressions and deeper water than any other ocean. Soundings exceeding 30,000 ft. are confined to the Pacific. In the Atlantic the deepest sounding is 27,972 ft. near the West Indies. The deepest Indian Ocean sounding is 22,968 ft. near the East Indies. Nine-tenths of the Pacific sea-floor are covered by water exceeding 6,000 ft. (over one mile) in depth. Nearly three-quarters are covered by water exceeding 12,000 ft. (over 2 miles). A comparison of the Pacific with the Atlantic shows the following striking differences:

Depth feet	*Pacific* sq. miles	*Atlantic* sq. miles
Between 0– 6,000	7,174,000	11,388,000
6,000–12,000	12,531,000	7,531,000
12,000–18,000	44,000,000	19,539,000
18,000–24,000	4,412,000	2,848,000
Over 24,000	201,000	15,000

The Pacific's volume is more than double that of the Atlantic. It is six times that of all the land, above sea-level, on the planet. The Pacific deeps have not been explored as thoroughly as have those of the Atlantic. In all oceans there are large areas which practically are unknown. Oceanography as a science is yet in its infancy. In the North Pacific is a tract twice as large as the United States which has been crossed by only a single line of soundings, taken at intervals about 250 miles wide. A number of other areas as large as the United States remain today entirely unfathomed.

The Pacific Ocean consists mainly of one enormous basin, with a total area of thirty million square miles—a surface *twice that of Asia*. This vast expanse is bounded on the west by the New Zealand, Tonga, Marshall, and Marianne ridges; on the north by the island chains which demarcate the North Pacific fringing seas; eastward by the North American coast and the great Easter Island Rise; and southward by the Antarctic shelf.

The Eastern Pacific is uniformly of great depth, mostly exceeding 12,000 ft. (2 miles). It has few volcanic islands and only a few small deeps. The western Pacific contrasts forcibly with the eastern. It has innumerable small volcanic and coral islands, together with such great continental islands as New Zealand, Borneo, New Guinea, and Japan. The western Pacific has large shallow areas alternating with extensive deeps of over three, four, and even five miles. The contour lines of depth are very irregular, with innumerable volcanic ridges almost or quite to the surface. The summits of these ridges are usually crowned with coral reefs, shoals or atolls.

The floor of the Pacific shows much sharper contrasts in rises and other depressions than do the other oceans. Murray states that along the west American coast the steep slopes are most remarkable. The land descends from the great heights of the Rocky Mountains and the Andes to depths of two miles or more within a very short horizontal distance. All Pacific soundings recorded in depths of over four miles have been taken comparatively close to land; for example near South America, the Hawaiian Islands, the Aleutian Islands, the Kurile Islands, Japan, the Philippines, the Ladrone Islands, the Pelew Islands, New Zealand, and the Kermadec Islands.

A map of the Pacific Ocean, showing the abysmal deeps, trenches and important island groups. Note the ring of deeps around the Hawaiian Archipelago, in the North Pacific Ocean. Reproduced from a colored map in Sir John Murray's "Depths of the Ocean"

The eight deeps of the Pacific, in order of magnitude may be listed as follows:

1. *Murray Deep.*—North of Hawaiian Islands, in central North Pacific, between 25°-40° N. lat. Covers an area (1,033,000 sq. miles) greater than the Sahara Desert. Maximum depth 21,240 ft. (4 miles).
2. *Tuscarora Deep.*—Close to Japan and Kurile Island, in western North Pacific. A gigantic trench, extending from 21°-52° N. lat. Its area (908,000 sq. miles) is larger than the Congo State in Africa. Maximum depth 27,930 ft. (5 miles). A considerable portion of this trench is over 4 miles deep.
3. *Aldrich Deep.*—Also called Kermadec-Tongo Trench. East of New Zealand, Kermadec, Tonga ridge, in central South Pacific, between 15°-47° S. lat. Its area (613,000 sq. miles) is nearly as large as Persia. In three or more places it exceeds 30,000 ft. (nearly 6 miles).
4. *Swire Deep.*—East of the Philippines, in the western North Pacific, between 4°-25° N. lat. Its area (550,000 sq. miles) is about the size of Honduras. Maximum depth 28,602 ft. (over 5 miles).
5. *Brooke Deep.*—Between Hawaii and Guam, in western North Pacific, between 12°-19° N. lat. Its area (282,000 sq. miles) is nearly as large as Borneo. Maximum depth 20,574 ft. (nearly 4 miles). It is separated by elevations of the ocean floor from the Challenger Deep to the west and the Bailey Deep at the north. With these it comprises the "Caroline Trench."
6. *Bailey Deep.*—Between Hawaii and the Marianne Island; between Brooke and Murray Deeps, 20°-25° N. lat. Its area (241,000 sq. miles) is nearly as large as Texas. Maximum depths 20,592 ft. (nearly 4 miles).
7. *Belknap Deep.*—South of Hawaiian Island, in the central North Pacific, between 12°-17° N. lat. Its area (165,000 sq. miles) exceeds that of Sumatra. Maximum depth 20,000 ft. (nearly 4 miles).
8. *Challenger Deep.*—East of Marianne Island, in western North Pacific, between 11°-20° N. lat. Its area (129,000 sq. miles) exceeds that of New Mexico. Maximum depth 31,614 ft. (the deepest recorded sounding).

The 33 known deeps of the Pacific, grouped geographically, are as follows:

I. *Fringing the Aleutian-Japan coast.*—Mayry, Supan, Tuscarora.

II. *Between the Pacific Coast (N. A.) and the Hawaiian Islands.*—Agassiz, Glover, Bache, Tanner, Moser, Gray.

III. *Surrounding the Hawaiian Archipelago.*—Murray, Wyman, Renard, Belknap, Ammen.

IV. *Between the Hawaiian Islands and the Philippine Islands.*—Bailey, Brooke, Challenger, Pourtales, Swire, Dana.

V. *Fringing the Andean Coast.*—Milne-Edwards, Kummel, Bartholomew.

VI. *Deeps of Australasia.*—Maclear, Wharton, Jeffreys, Weber, Planet, Thomson, Aldrich, Hilgard, Garrett, Campbell.

The Central Pacific's floor is an enormous, gently undulating plain, interrupted here and there by elevations. Vast stretches are practically level. Studding this icy, black, abyssal plain are steep-sloped submarine mountains. These are of various heights, some rising nearly to the surface of the water. They are usually incomplete volcanic cones.

The deep sea is absolutely monotonous to a degree unknown in terrestrial regions. In its extreme uniformity and monotony of environment it also markedly contrasts with the shallow water of the coasts. The abyssal plain is pitch dark; wholly devoid of sunlight: It is icy cold. Silence reigns supreme; the deeps are noiseless, and almost motionless. There are practically no diurnal or seasonal changes; day and night, summer and winter, are unknown in the abysses. There is an exceedingly slight and slow rhythm of tides, temperatures, and currents.

Icy and almost invariable temperatures prevail on the ocean floor. The bottom temperature is about the freezing point of fresh water. A temperature of 30°-35° F. characterizes nearly the entire sea plain of the South and North Pacific. The Central Pacific floor has a temperature between 35°-40° F.; 92 per cent of the world's sea floor is overlaid by water having a temperature under 40° F. The temperature is extraordinarily uniform throughout the depths of the Pacific. At all depths below 7,800 ft. (1.5 miles), the temperature is uniformly 36° F. In tropical areas, where the surface waters are warm (75°-80° F.), the temperature decreases at first very rapidly, and then more and more slowly toward the deeps. At the depth of a thousand feet the temperature is below 40° F. Not more than *one-fifth* of the total ocean water has a temperature of 40° F.; its average temperature is below 39° F. The very low temperatures of the abyssal Pacific have their origin chiefly in the Antarctic Ocean, the icy waters of which creep slowly northward. The rate of movement is exceedingly slow.

A striking contrast between surface and deep sea life in the tropical Pacific, and in all warm seas, is found in the metabolism of plants and animals. The surface creatures, in warm water, live at high speed. The life processes of the abyssal animals is exceedingly slow. Sluggishness, torpidity, physiological inertness—these are distinctive of deep sea life. *The lower the temperature the slower the life reactions.* This law affects not only the life of the individual, but also of the species. All evolutionary processes are greatly retarded by the icy environments. In many life features the deep sea organisms show marked resemblance to those which inhabit polar regions.

An excellent example of the metabolic difference between surface and deep is afforded by lime-secreting plants and animals. In the warm surface waters reef-building and other kinds of lime deposition goes on with remarkable rapidity. In the ice-cold deep waters, however, there occur *no* important lime-secreting forms. The calcareous deposits, such as Globigerina Ooze, that are so abundant throughout many ocean depths, originate in the superficial waters, and sink to the bottom as dead skeletons.

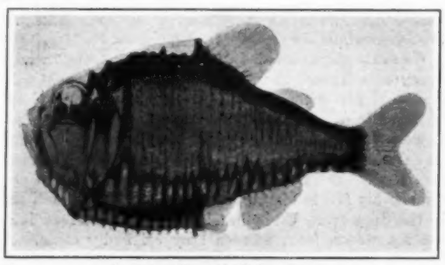
The colder the water the more *viscid* it becomes. Viscosity, that is, internal friction, increases with decrease in temperature. Deep water is notably viscid. At 77° F. seawater has a viscosity of 53; at 50° F. of 76; and at 32°. of 103. In other words, in the tropical Pacific the deep waters are *twice* as viscid as those of the surface. The same body sinks twice as rapidly through the surface waters as through the abyssal waters.

Suppose you are on a ship, far from land. You toss a small object overboard and see it disappear in the inky-blue waters. The further it sinks, the *slower* becomes its fall; its downward motion does not cease until it rests on the bottom, but is progressively retarded. Fine particles, volcanic dust, and other minute matter, settle to the ocean floor with inconceivable slowness. Imagine a snow storm in which the flakes descend with incredible slowness, and you have a picture of the tedious unceasing deposition of solid particles upon the ocean floor.

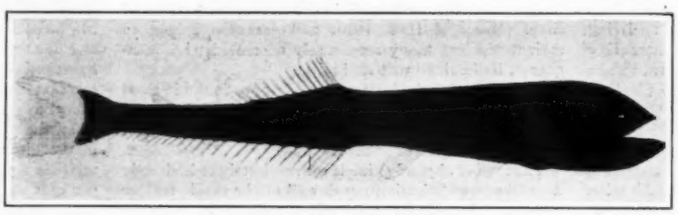
Many deep sea animals, the hydroids for example, have developed special apparatus for catching the minute food particles that continually fall from the surface waters. In the deep seas it literally rains manna.

The enormous pressure in the deep waters is difficult to conceive. The atmospheric pressure, to which man and terrestrial organisms are subjected, at sea level is 15 pounds per sq. inch. The oceanic pressure at 18,000 ft. is *3.6 tons* per sq. inch. At 24,000 ft. depth this increases to 4.8 tons per sq. inch, and at 30,000 ft. (6 miles) to 6 tons per sq. inch. This pressure is so great that if gravity were to suddenly cease, the ocean's surface would instantly rise 200 ft. In the Pacific this would be sufficient to entirely cover thousands of atolls and low coral islands, in many instances converting whole archipelagoes into banks and shoals. Most of the lesser islands of the Hawaiian group, for example, would be wholly submerged.

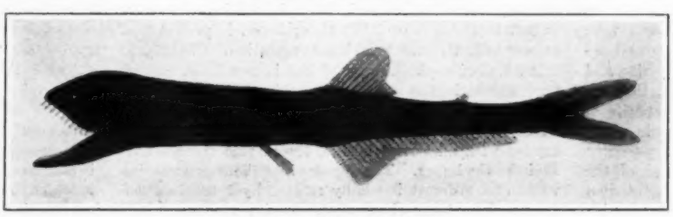
Contrary to popular notion, water is almost incompressible. The abysmal layers are not perceptibly denser than the surface waters. Anything that will sink in an ordinary glass of water will sink to the bottom of the deepest sea. This is completely demonstrated by the fact that the ocean floor is strewn with delicate lime and quartz skeletons of pelagic organisms.



Argyropelecus affinis, Garm



Gonostoma grande, Collett



Gonostoma Elongatum, Gthr

Three representative deep-sea fishes, carnivorous and fully equipped with luminous organs. The light producing structures are seen as rows of light spots or patches along the lower sides of the body. Reproduced from a colored plate in Sir John Murray's "Depth's of the Ocean"

Unprotected thermometers and other sealed glass vessels sent down to great depths in dredging operations are "imploded" (the reverse of exploded) and crushed to snow-white powder. When a ship sinks, for example, every tightly sealed article or cavity in the vessel is blown in by the terrific pressure. In any wooden material the minute cells of the wood are destroyed and the wood becomes completely "waterlogged."

On the other hand, the tissues and functions of the most fragile deep sea animals are but little disturbed by the enormous pressure. This is due to the fact that equilibrium is maintained inside and outside the body. Most of these creatures are so soft that when withdrawn from the pressure which keeps them in a firm condition on the bottom, and brought to the surface, they quickly disintegrate unless special precautions be taken. The bones of abyssal fishes are very cartilaginous. These marvelous adaptations to pressure have been very gradually acquired over great periods of time, as the creatures have slowly invaded deeper and deeper waters.

When a deep sea fish for any reason happens to rise above the depth to which it is accustomed, the diminishing pressure causes its swimming bladder to expand. Its specific gravity is thus greatly reduced. Up to a certain limit the fish can voluntarily counteract the tendency to float upwards, but beyond this it is helpless, and goes on *"tumbling upwards"* to the surface. It is gradually killed during its ascent by the distension of its organs as the pressure decreases.

The Pacific Ocean, like all deep seas, is divided into two great horizontal zones. The surface stratum is the *photic zone*, or region illuminated by sunlight. In the open sea its depth is 3,600-5,400 ft. Below this photic zone lies the much vaster and deeper *aphotic* stratum, the mysterious realm of absolute darkness, save for occasional ghostly animal luminosity. Although the total penetration of sunlight is nearly one mile, most of the heat and light waves are absorbed in the uppermost few hundred feet—first the heat waves, then the red, then the blue, and lastly the actinic or ultra-violet rays. We are likely to think superficially of our planet as bathed in sunshine, with half the surface continuously exposed. As a matter of fact most of the earth's surface is wholly screened from sunlight by ocean water, and much of the remainder is hidden under deep layers of cloud and fog.

The deep seas are absolutely sunless. Luminous rays from animals appear to be of much biologic importance throughout the whole zone. Light-producing organs are highly developed and occur in great variety in the "twilight zone" fauna. They are relatively rare in the animals of the cold abysses. Luminosity is widely distributed through nearly all groups of marine plants and animals, from bacteria to fishes. This is extremely significant, as luminosity is unknown in fresh-water life. No luminous creatures have ever been found in fresh water. Recent studies in luminosity show that this quality is much more common in protoplasm than was formerly supposed. Its functions are but imperfectly understood.

The vision of abyssal animals shows the greatest variation, from total blindness to large and highly specialized eyes. Most, if not all, bottom dwellers have large eyes. The deepest fishes known, which migrate freely over all the abyssal plains, have very large eyes. They probably capture their prey by their own luminescence and that shed by the other creatures that are constantly flashing their faint lamps over the ocean floor. All deep sea fishes have only *rods* in the eye retina. These elements have the power of distinguishing light intensity, but *not* color. Color is perceived only in the *cones*, and these latter elements are wholly absent from the eyes of deep sea fishes.

The colors of deep sea animals are usually as brilliant as those of animals living under the influence of light, though not so varied. The reds, yellows, purples, and greens predominate. The colors are apt to be in solid masses, in striking contrast, or the whole animal is of a uniform brilliant coloration. There is a conspicuous absence of blue. The fishes, as a rule, are dark-colored, but many of the crustaceans, holothurians and starfish are brilliantly pigmented.

The movement of abyssal waters is exceedingly slow. There is a gradual bottom creep of icy water northward from the Southern Ocean. Although all water movement in the deep Pacific is infinitesimally slow, there is *nowhere* absolute stagnation. All ocean water, however deep, is in circulation. Numerous analyses prove the presence of absorbed oxygen everywhere. The atmospheric gases are absorbed at the surface, especially in cold regions, and are carried, by slow circulation, down to the uttermost depths.

The saltiness of ocean water diminishes from the surface to a depth of 4,800-6,000 ft. and then increases to the bottom. The bottom waters of the Pacific have almost uniformly a salinity of 34.8 per mile. They correspond closely with the bottom waters of the South Atlantic.

The deposits which cover the Pacific deep sea floor are classed in five groups:

1. *Red Clay*, volcanic dust, etc., all very deep waters.
2. *Diatom Ooze*, one-celled plants, glassy skeletons, polar and temperate waters.
3. *Radiolarian Ooze*, one-celled animals, glassy skeletons polar and temperate waters.
4. *Globigerina Ooze*, one-celled animals, limey skeletons, tropical and temperate waters.
5. *Pteropod Ooze*, small molluscs, limey skeletons, tropical and temperate waters.

In the central regions of the Pacific basins land-detritus is almost wholly absent from the deposits. On the rises and in the basins of moderate depth in the open sea, the organic oozes preponderate, but in abyssal depressions below 15,000-18,000 ft. whether these lie in the middle or near the edges of the ocean spaces, there is found only the Red Clay.

Three-fifths of the entire Pacific bed, an area of 39 million square miles, is covered with chocolate-colored mud, the "Red Clay." The reddish brown color is due to the oxides of manganese and iron; the clays them-

selves are mostly of volcanic origin. This deposit is characteristic of the greatest depths, for example, below 16,000 ft. in all oceans. It has not been found at depths of less than 13,000 ft. It is the most widely distributed of all the deep sea deposits, and covers a larger area than any other. Red Clay is the dominant submarine deposit of the water hemisphere, as Globigerina Ooze is the characteristic submarine deposit of the land hemisphere. Red Clay is the typical deposit of the Pacific abysses, and there attains its maximum development. Associated with it in vast numbers are nodules of manganese and iron, together with the teeth of sharks, and the earbones and other bones of whales. Red Clay is plastic while fresh, but dries to a stoney hardness. It contains a very small amount of lime, less than 1 per cent, and thus sharply contrasts with the shallow water deposits, which are rich in lime. Red Clay is deposited at an inconceivably slow rate. Probably not more than a few feet have been added since the Tertiary period. There is undoubtedly no other deposition on the planet which is proceeding so infinitesimally slowly.

The Red Clay, although occupying vast areas and of volcanic origin, is not the sole inorganic deep sea deposit. Volcanic dust, pumice, and glass is abundant in many deeps. Much of this volcanic debris is of great antiquity and evidently floated in the surface waters for a long time before sinking to the abyssal plain. Cosmic dust particles, derived from "falling stars" or meteorites, is also typical of the great Pacific deeps. These bits of "star dust" are minute black and brown spherules, and possess magnetic properties.

The siliceous or quartz-like deposits in the Pacific are chiefly from radiolarie and sponges. The sponge spicules are abundant and widely distributed, but never occur in great quantity in any one place. Radiolarians are microscopic one-celled animals, with radiating branches, and beautiful glassy skeletons. These tiny creatures occur in prodigious swarms in the warm waters of the central Pacific. Their skeletons are so plentiful in certain regions as to constitute the bulk of the deposits. Radiolarian Ooze has been found in seven localities in the central Pacific, between 15° N. lat. and 10° S. lat.

Diatom Ooze occurs in detached areas between the Philippines and Marianne Islands, and near the Aleutian and Galapagos groups. These comprise exceptions to its typical range, which is in high latitudes only. Diatoms are microscopicone-celled plants, with glassy skeletons or shells. These are often sculptured with exquisite delicacy. The ooze is yellowish-gray or straw-colored while wet; upon drying it becomes white and mealy. There are over 1,500 kinds of diatoms; they are exceedingly abundant in cold seas. Great deposits of diatom shells in Virginia, Nevada, and California prove that these regions were once old seabottom.

Globigerina Ooze is the typical chalky mud of the Atlantic, where it covers 17 million square miles, just as Red Clay is typical of the Pacific. In the Pacific Globigerina Ooze covers 11.5 million square miles. It occupies the intermediate depths of the west and south Pacific, but is unknown in the northeast part of the basin. Globigerina are microscopic animals which construct limey shells of several tiny globose chambers. Upon drying, the ooze becomes chalk or limestone.

Pteropod Ooze is merely a local variety of Globigerina Ooze, in which the comparatively large but very delicate spindle-shaped pteropod shells happen to abound. Pteropods, literally "wing-footed," are small swimming molluscs that are very abundant in certain Pacific waters. The shells, in sinking, disintegrate below 8,500 and 9,000 ft., so that this ooze is found only in small patches on the submarine ridges. In the Pacific it is known only in the neighborhood of the Fiji, Paumotu, and other archipelagoes of the southwest Pacific, where it occupies the zone below the fine coral sands and muds.

An extraordinary phase of Pacific deep sea exploration has been the discovery of *great radio-activity* in the abysmal deposits. These are much richer in radio-active substances than are the average terrestrial rocks. The Pacific Red Clays and Radiolarian Oozes, which are laid down in very deep water far from land, contain the maximum amounts of radium. These facts are of profound significance, and are prophetic of researches in the future which may be of great importance to mankind.

A monumental advance in knowledge, due to deep sea studies, was the discovery that living creatures exist in *all* parts of the ocean. On the dry land organisms do not rise very high above the surface, or penetrate very far below. In the ocean, however, life is present *everywhere*, from the surface to the most profound abysses. Life is not only exceedingly abundant in the ocean, it is very widely distributed. No part of the Pacific is known to be barren of life.

The greatest profusion of bottom-living forms characterizes coastal waters. There is a gradual decrease in abundance as one proceeds farther and farther from land into deeper water, until a minimum, but *not* a zero, is reached in the Red Clay areas of the abyssal plain. The most abundant Pacific deep sea animals are the holothurians and other echinoderms.

The assertion is frequently made that, due to the absence of sunlight, there are no living plants in the oceanic depths. It is wholly probable, however, that the bacteria of putrefaction, and perhaps other fungi and saprophytic forms, exist in the deepest abysses. Otherwise it would be difficult to explain the decomposition of the soft parts of fishes, whales, and other marine animals. Were it not for saprophytic bacteria, the Pacific abyssal plain would be thickly covered with refrigerated corpses.

The skeletons or remains of plants are relatively rare on the sea floor, when compared with those of animals. The most common plant remains are the shells of lime- or silica-secreting algae. Diatom Ooze, as has been indicated, is plentiful in cold waters. The floating lime-shelled algae, however, are so fragile that their shells are dissolved before they reach the ocean floor.

Whereas plant remains of the deep sea are mostly glassy or siliceous, the animal remains are chiefly calcareous. The limey skeletons of many different kinds of animals, ranging from microscopic foraminifera to gigantic sharks and whales, abound on the abyssal plain. The Globigerina and Pteropod Oozes have already been described; the Radiolarian Ooze is glassy. There are remarkably few fish bones, aside from teeth and otoliths, in the deep sea. Undoubtedly they are dissolved into the sea water, from whence they originally came. A large proportion of limey skeletons never reach the ocean floor. The teeth of sharks and the earbones of whales are typical of the vast Red Clay plains, especially in the Pacific. Here they have lain for enormous periods of time. Many of these teeth and earbones belong to extinct species; many are densely encrusted with manganese, indicating great antiquity.

Traces of albuminoid organic matter are found in most deep sea deposits. This material is derived from the bodies of scavengers and mud-eating animals that creep about on the oozy floor.

The food of abyssal animals comes directly or indirectly from the vast "floating meadows" of the sunlit surface waters. These limitless, densely crowded swarms of one-celled algae supply food to all the sea's denizens. The rich and diversified pelagic flora, inhabiting the upper waters to a depth of 1,500 ft. or more, is probably of greater bulk that the total land vegetation.

If all marine plants were placed in one heap, and all land plants in the other, the marine heap would undoubtedly be much larger than the terrestrial heap. If all marine life, plant and animal, were similarly contrasted with all terrestrial life, the marine group would again be the larger. The popular idea that the ocean is a waste and a desert is wholly refuted by the actual evidence. The facts show that, despite the many disadvantageous conditions of marine existence, plant and animal life has developed there more abundantly, though not in so great variety, as on the land.

The quantity of food rapidly decreases as the depth increases. The great Pacific Red Clay areas are practically foodless, and hence barren of animal life. The muds and oozes of the lesser deeps contain organic detritus from higher levels, and are the sources of food for the bottom feeders. The deep sea echinoderms, for example, always have their intestines crammed with the surface layers of the deposit on which they are captured. The bottom-dwelling animals are mainly mud-eating scavengers. They in turn are devoured by predatory carnivores.

In the deep seas the relative rarity of rocks, ledges, etc., lead to marked absence of sessile or attached animals. The soft oozes and slimes are not suitable for these forms. In general it may be stated that the nature of the bottom determines the character of the fauna. Many typical deep sea animals have long stalks lifting the bodies out of the mud (crinoids); others have long legs (crustaceans); others have well developed tactile organs (fishes). Many are delicate in structure but of gigantic size when compared with their shallow-water allies. Species requiring lime for their skeletons—molluscs and corals—are but feebly developed in abyssal regions.

The deep sea Pacific fauna is poor in species and meager in individuals. The species are wide ranging—in many cases almost cosmopolitan—over the ocean floor, but are scarce in any given situation. This condition contrasts with the abundant animal life of the 8,000-10,000 ft. zone, where the fauna is infinitely richer in species as well as in number of individuals. The most typical deep sea fishes of the Pacific are the Macrurids or morays, which are plentiful in Hawaiian waters.

Whence came the strange denizens of the abyssal plain? Researches in their genetic relationships show that they have migrated from the shallower seas surrounding the continents. As the shallow waters became stocked to the extreme limits of their food capacity, the pressure of over-population inexorably forced certain forms into deeper water. These became the deep sea creatures. They are modified in many details, as a result of their abysmal environment, yet on the whole they are much more archaic than are the shallow water forms.

The abyssal Pacific is scarcely known to man. Adequate explorations will be the task of the next centuries. Deep sea surveys are expensive and laborious. Their returns are apparently meager, but they are of the highest scientific value and interest. Man can never fully know himself until he knows fully the planet upon which he has been created.

The Pacific is a region of great subsidence. Mountain peaks, ranges, and perhaps entire continents, by inexorable earth changes have been dragged beneath its vast expanses. The Pacific holds the key to many large problems of biology and human life. The twentieth century should be marked by a comprehensive and detailed survey of the Pacific.

A Neglected Chemical Reaction and an Available Source of Potash

THERE is a reversible reaction between dry sodium chloride and orthoclase felspar when heated together in a state of fine division in the absence of air or moisture. In the state of equilibrium the distribution of the alkalis depends on their relative proportions:—$2NaCl + K_2O$, $Al_2O_3,6SiO_2 = Na_2O$, $Al_2O_3,6SiO_2 + 2KCl$. If the felspar (10 per cent K_2O), crushed to pass a 100-mesh (I.M.M.) sieve and mixed with its own weight of salt, is heated for two hours at 900 degrees—1,000 degrees C., 85 per cent of the potash will be converted into a soluble form without loss by volatilization. A temperature above 1,100 degrees C. is to be avoided as conducing to fritting, while the presence of air and moisture leads to loss of alkali and destruction of any metal containers by chlorine and hydrogen chloride evolved. The reversibility of the reaction was demonstrated by heating the product of the above reaction with excess of potassium chloride, when the potash felspar was regenerated. The product of the direct reaction as above yields on lixiviation a mixture containing about 90 per cent of NaCl and ten per cent of KCl, which can be separated by crystallization. It is suggested that the reaction should be applied to the extraction of potash from British felspars. Apart from the expensive high-grade felspars used in pottery manufacture, there is a large quantity, estimated at 20,000,000 tons at least, of pegmatite exposed on the extreme northwest coast of Sutherlandshire, Scotland. It contains 8 per cent of K_2O and its estimated cost, quarried and picked, is 2s. 6d. per ton, on a site well suited for the erection of works for treatment and favorable as regards conditions of water-borne transport. It is suggested that a form of vertical retort might be used in which molten salt percolates a heated charge of felspar. Alternatively the charge might be placed in iron boats, closed with lids, and pushed through a heated horizontal gas retort in which an atmosphere of producer-gas is maintained. The boats would form a continuous train and would remain for two hours in the hot zone and one-half hour in the cooling region. It is estimated that 80 per cent KCl could be produced in normal times at a cost of £7 per ton, thus competing favorably with German supplies. The analytical methods for dealing with mixtures of potassium and sodium chlorides are discussed. The "indirect method" based on the estimation of the total chlorine is recommended as accurate to within one per cent if care is taken and the mixture titratedagainst silver nitrate is free from chlorides of other metals. Iron, manganese, calcium, and magnesium are removed by boiling first with ammonium carbonate and filtering, then with a crystal of oxalic acid, and again filtering, and evaporating to dryness with hydrochloric acid. The residue dissolved in water is titrated with $N/10$ silver nitrate, using weak chromic acid solution as indicator.—Note in *Jour. Soc. of Chem. Ind.* on a paper by E. A. ASHCRAFT before the Institute of Min. and Met.

Hybridization Experiments

IN the NIEUWE COURANT Dr. I. P. Lotsy recently directed attention to the hybridization experiments of Mr. R. Houwink, a private breeder of Meppel, Holland, who has tested Darwin's view that our domestic fowls are derived from *Gallus bankhiva*. He has obtained fertile hybrids of this species with *G. Sonnerati*, and also with *G. furcatus*. The latter hybrid was again fertile with *G. bankhiva*, whence it would appear that all three species may be among the ancestors of domestic breeds. Domesticated rabbits have been found fertile both with wild rabbits and with hares, and hybridization experiments are also in progress with jackals, foxes, and wolves, in order to determine the origin of domestic breeds of dogs. Experiments on the crossing of wild and domesticated pigs are subsidized by the Dutch Government.—*Nature*.

Ordnance on the Allied Front—II*

Developments in Artillery During the War

By John Headlam, Major-General, in Charge of the British Artillery Mission

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CARE OF AMMUNITION

But however solidly a gun may be supported it can not be expected to give uniform results unless the ammunition is in good order. Powder and fuses must be protected from the weather, and this entails much labor and constant care. We had, for instance, great trouble when we first adopted nitro-cellulose powder because we did not realize how sensitive it was to damp.

Protection from the weather is not, however, all that has to be done to insure good shooting from the ammunition. Cartridges and fuses are made in *lots*, and no "adjustment" can quite get over the differences between these. Every effort is made to keep lots together, and the system of doing so is at this moment being greatly developed, but even with all possible care, lots will inevitably get mixed in their passage from the factory to the ship, from the ship to the depots, from these to the dumps, and so through the various échelons of supply till they reach the guns. Cartridges and fuses must therefore be sorted in the batteries, and the necessary allowances made when using the different lots. Somewhat the same thing has to be done with the shell, for when a large output of ammunition is to be obtained from all sorts of factories it is out of the question to reject all which are not exactly within the strict limits of weight. They are accepted but with the weight marked upon them, and these again must be sorted and the necessary allowances made.

CALIBRATION OF GUNS

The next thing the artilleryman has to think of is the age of his gun, or rather how hard it has lived! As a gun wears, its accuracy and its range fall off. The former can not be calculated, though it must be allowed for: the latter can, and the loss of muzzle velocity in each gun must be found and allowed for. This is what we call "calibration," and it has to be repeated with each propellant, and, in a howitzer, with each charge. It is usually carried out on the front, because we prefer, whenever possible, that every shell should have at any rate a chance of killing a German. To enable it to be done the topographical sections provide batteries with maps, mounted so as to avoid errors due to shrinkage or warping, and showing accurately not only the positions of the guns and observing stations, but also such datum points as may be desired in the enemy's lines.

ERROR OF THE DAY

Having by this means found the errors of the guns, a battery commander has next to think of the error of the day, rather of the moment. He must ascertain and allow for the height of the barometer, the temperature of the air, the temperature of the charge, and the force and direction of the wind for a given time of flight, and here he has to depend on his scientific friend "Meteor" who sends to him every few hours cryptic telegrams.

ERROR OF THE GUN

And yet after all this meticulous care, we have to recognize that a series of rounds fired at the same elevation will not fall on the same spot, but will cover a rectangle varying in size with the gun and the range. The size of the "50 per cent zone"—the length and breadth of which are a quarter of those of the 100 per cent zone—is given in the range table of each gun, and this has to be continually in the mind of the battery commander, for without a thorough realization of it he cannot judge how many rounds will be required to accomplish such a task, as, for instance, the destruction of an enemy's battery. But its most important use is perhaps to avoid danger of shelling one's own troops. Nothing is so distressing to an artillery general as to receive complaints from the infantry that his shells are falling in their trenches, and yet whatever the skill of his batteries this must happen sometimes, with the lines as close together as they are, unless this inherent quality in the gun is recognized and allowed for.

DIFFICULTY OF APPLYING CALCULATIONS IN THE FIELD

I will not pursue the subject further, but remember that though the calculations may appear very simple to you, they are not so easy, given the conditions under which they have to be made—the absence of any conveniences, the presence of every disturbing element. It is very easy then to make an error which may have fatal results. One of my best battery commanders was killed by a shell from his own battery when himself conducting the fire from a trench from which he had cleared the infantry.

OBSERVATION OF FIRE

But however confident he may be of the accuracy of the information furnished to him by his scientific assistants, and of the correctness of his own calculations, the good artilleryman will always do everything in his power to insure his fire being *observed*. The possibility of sending artillery officers forward with the advancing infantry had been hotly debated before the war and in some cases practised as far as this could be done in peace, so it did not take long to fall into the idea when the first halt on the Aisne gave the opportunity—and the demands that the work made on the enterprise and ingenuity of our officers caused it to be taken up with enthusiasm. The following example may bring home to you some idea of what this meant.

At one point on the Western Front there was a low ridge between the opposing front lines of trenches. Beyond the end of this ridge there was an offset in both lines. There were ammunition dumps behind the ridge and beyond the offset stood the ruins of a farm-house, from which a good view could be had of the German positions behind the ridge. One of our battery commanders discovered that he could get up to that farmhouse at night. He went up one night and explored it and found that there was a gable still standing, and that the end of the gable had been knocked out by a shell, but that there were strips of drying tobacco hanging in the opening which he thought would give him shelter. So he got his telephone up there the next day, after many difficulties; he was only about 150 yards from the German lines. There he carried out a shoot which is a good instance of what I said about the importance of accuracy. Here was the ridge, and our trenches were just short of the crest. He wanted to shoot at the point beyond the crest. It was extremely difficult from the gunner's point of view to get a shell which would clear this crest and hit the objectives desired, for there was danger that the shell would hit the crest or drop into our own trenches. He succeeded through his control of the fire by direct observation, although he had to carry all that out in a place where he could not move and where he was really in full view of the Germans almost within pistol range. It was one of the sort of problems that artillery officers are continually attacking and solving in this war.

AEROPLANE OBSERVATION

Almost simultaneously the aeroplane observer entered the field. The story of how the present system of communication between aeroplanes and artillery has been gradually developed is in itself a subject for a lecture. Now not only does the observer in the air observe our fire, he also proves the correctness of his observation by bringing in a photograh of the result, which is used also by comparison with the zone of the guns to check the accuracy of the work of the battery. I need hardly refer to the science that has been devoted to developing the means of communication and perfecting the system, but all those who have had real experience whether they belong to the Flying Corps or the Artillery, will I am sure agree that success will never be attained without the closest possible personal touch and sympathy between the observer in the air and the gunner below. They must know each other—without the personal equation, half the benefit of science is lost.

But practical experience showed the danger of relying too exclusively on aeroplane observation as liable to be put out of action by bad weather, while in any case the number of machines which can work on any given front is strictly limited. Great efforts are now therefore being made to develop all other possible means of observation. The balloon—the first cousin to the aeroplane—is of course very restricted in its zone, but it has the great advantage that the observer in it is in direct telephonic communication with the artillery—indeed it is nothing but an observing station in the air, which can be occupied by any artillery officer.

OBSERVING STATIONS

The ordinary observing stations have been developed in the one direction by camouflage which was first directed to this end, rather than to the concealment of the guns themselves; then to their elaboration—instead of the officer covering behind his precarious screen of tobacco leaves, he would be in a comfortable splinter-proof tower which had been ingeniously built inside the ruins; or sitting in the cellar, with his eye to a giant periscope, or perhaps a camera obscura.

FLASH-SPOTTING AND SOUND-RANGING

In the elaborately equipped observatories of the "flash spotters" the burst of every round may be accurately recorded by the intersections of three widely separated observers, and instantaneously transmitted to the plotting stations. There too will be registered the position of any gun that is foolish enough to open fire from an insufficiently masked position when the clouds are dark behind it.

Then the "sound ranger" too plays his part, as with his delicate instruments he registers the discharge of the enemy's gun—also, often enough, the burst of the enemy's shells. Their work must be done far to the front, and often with little or no protection, and I would like to bear witness to the gallantry of the distinguished savants who have let no consideration of personal safety or comfort interfere with the accuracy of their observations.

*A lecture given before the Washington Academy of Sciences on April 3, 1918. From the *Journal of the Washington Academy of Sciences*. Communicated by Mr. L. J. Briggs.

Reduction of Highly Reactive Metals and Metalloids

Very fine subdivision of the material is obtained in a steel bomb which acts both as grinding mill and reaction chamber. The bomb is charged with a mixture of titanium chloride or potassium zirconium fluoride and pieces of metallic sodium; several hard steel balls, 2 cm. in diameter are added, and the bomb is sealed with the aid of fused lead and kept revolving for 40 hours at 200 degrees C. The temperature is then raised to start the reaction, which is completed in a few minutes. The bomb is afterwards cooled from the top downward, and the lead removed. In this way a titanium powder was obtained which melted to a silvery, slightly yellowish metal of 99.7 per cent; the zirconium was 99.3 per cent pure. Very little is said about the products, but the difficulties experienced in the isolation of boron, and the apparatus used for this purpose, are fully described. By the process mentioned boron could only be obtained as a black powder which reacted with the gases in the bomb (hydrogen, nitrogen, CO, and CO_2). Electro-thermic reduction of boron chloride with pure iron wire proved no more successful. The oxide B_2O_3 is first converted into the white, refractory nitride BN by being heated in an atmosphere of nitrogen or ammonia; the nitride (and also boron carbide), is the material for the frame on which the iron wire is wound and for the furnace tube; the furnace consists of an iron cup and an iron tube, and in this furnace BCl_3 is reduced. The furnace is first charged with hydrogen, which is then expelled by BCl_3. The reduction being at 800 degrees, but iron boride being also formed, the temperature must be raised to 1,700 degrees. The resulting boron volatilized completely when heated in hydrogen; in the blowpipe it was burned to nitride and some oxide. Boron wire, free from iron, did not melt even when an electric arc played between two pieces of wire; but it was brittle, and impurities greatly affected its properties.—Note in *Sci. Abstracts* on an article by E. Podozus in *Zeits. Anorg. Chem.*

Gas from Straw

The author discusses the possibilities of straw as a source of gas, more particularly in Canada, where great quantities of straw are wasted annually. Straw is compressed in a baling machine to a density of 25 pounds per cubic foot, and inserted in a retort of highly refined steel, 7 feet 6 inches long, 24 inches wide, and 6½ inches deep, enclosed in a casing with fire-box below. The total cost, including a scrubber and gasholder, in Canada, is about £105. The temperature reaches a maximum between 500 degrees and 600 degrees C. and all the gas is removed in about 30 to 45 minutes. Each ton of straw gives 11,000 to 12,000 cubic feet of gas, 6 to 8 gallons of tar and ammoniacal liquor, and 600 pounds of carbon residue (lampblack). About 30 per cent of the gas is used to assist the carbonization, leaving a surplus of 7,000 cubic feet of a calorific value of 400 B. Th. U. per cubic foot, equivalent to 25 gallons of petrol. The gas consists of methane, hydrogen, and carbon monoxide and may be used in the same manner as coal gas.—Note in *Jour. Soc. Chem. Ind.*, on an article by R. D. McLauren in *Gas Journal*.

Photo by the Gillhams Service

Driving in sheep from the range

Prize black-face sheep raised in Canada

The Wool Product Dwindling

War Demands Have Caused a World Shortage

THE war has produced an acute shortage in wool the world over, our sheep alone have decreased more than 13,000,000 since 1900, and to supply clothing to prevent an epidemic of nudity, if war lasts a great while longer, substitutes for wool must be found. Germany, which is worst off of all nations, has already taken to paper clothing and other nations including the United States, are beginning to consider seriously the use of paper instead of wool cloth whenever possible.

The art of forming wool into cloth and stuffs has been known in all civilized countries, since remote ages. Woolen cloths were an article of commerce in the time of Julius Caesar and are familiarly alluded to by him.

But the art of making paper into cloths belongs to the present age, and is largely an outcome of the great war and the tremendous scarcity of wool due to the great increase in demand for the same and most alarming decrease in sheep raising.

The armies require immense quantities of wool in the manufacture of clothing, and the enormous extra demand for meat is taking the lives of large numbers of sheep in all the warring nations.

In France the number of sheep have decreased nearly one-third since war began. In Turkey sheep and goats have been slaughtered by the millions to feed the soldiers, and as they mostly belonged to the Armenians, the Government has taken no steps to replace them. Serbia lost her live stock to the invaders and practically all of her sheep. England's wool clip has decreased fully twenty-five per cent since the outbreak of the war.

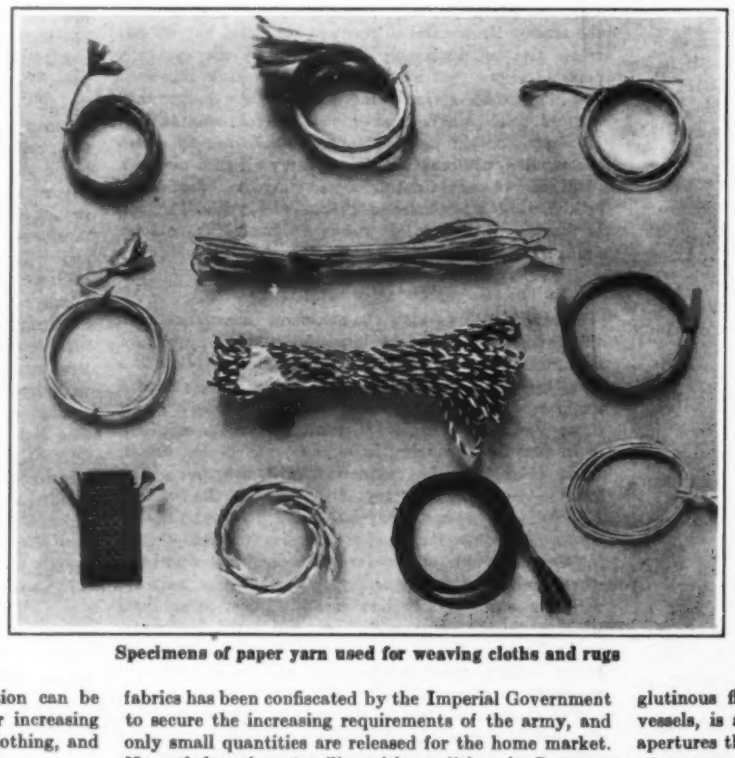
In the United States we are not much better off as the number of our sheep have decreased more than 13,000,000 since 1900 and the population has increased fully 25,000,000; besides our war demands for wool are enormous. In Germany, however, the wool situation is most acute of all, her famous Saxon and Silesian wool has almost gone out of the market because of the slaughter of so many sheep, while Austria has first chance at the fleeceable sheep of Hungary and Serbia. As matters stand, Germany's own wool production, added to all the other conquered territories can be made to yield, covers, it is reliably reported, but a fractional part of the army's requirements alone. The solution can be only that of manufacturing shoddy of ever increasing shoddiness as the war lengthens, or paper clothing, and Germany has already come to this.

In fact that the Huns are in no danger of being threatened by an epidemic of nudity at some distant future stage of the war is entirely due to the sensational turn in the development of the paper thread industry, culminating in the technical triumph of practical wovenpaper materials. What started as a seemingly visionary emergency experiment shortly after the war began has been perfected into a process of permanent value. German cloth weavers have avoided closing down by adapting their plants to paper thread and paper yarn spinning, on which thousands of once idle looms are running again. Cotton goods and jute makers have also eagerly gone in for paper weaves from coarsest to finest qualities.

In the opinion of experts, not only in Germany, but also in this country, the new industry born of this war is still only on the threshold of wonderful development. It is prophesied that after the war the production of paper fabrics will assume such proportions that the time may come when the importance of wool, cotton and jute will by no means be as great as it is today. Germany is greatly hoping this condition will be brought about as she believes it will help to restore her unfavorable trade balance and boost up the fallen mark exchange.

There is no doubt that the new paper fabric industry of Germany has reached a point where it could turn out with no great difficulty wearable substitutes for all necessary articles of clothing heretofore made of wool. The German public, however, being conservative has up to date shied at the "paper clothes."

The manufacturers' enthusiasm for educating the public down to wearing paper has been further limited by the fact that the entire production of paper thread and fabrics has been confiscated by the Imperial Government to secure the increasing requirements of the army, and only small quantities are released for the home market. Nevertheless those familiar with conditions in Germany believe the time is bound to come when Germans in large numbers will be forced to choose between wearing paper or nothing.



Specimens of paper yarn used for weaving cloths and rugs

Today not an outer or undergarment, not a piece of clothing except it be made of paper can be bought in Germany without a permit issued on personal application to the police and only after a hearing, sometimes involving cross-examination and sworn affidavit that the clothing in question is sorely needed by the applicant. Frequently it is necessary, and generally, to expedite the permit, desirable to bring along outworn garments as evidence of necessity.

With the English and Canadian woolen market to draw upon, to a limited extent at least, as well as our own, the war will likely have to continue for some time before we Americans will of necessity be as close to paper clothing as Germany is at this moment. Nevertheless it is a fact that since the opening of the war and wool has become more and more expensive, the shoddy industry in America has grown by leaps and bounds, and growing tired of buying clothing, much of which is sold as "all wool," but which is really perhaps only burlap, into which macerated rags and fur have been blown or pressed, we may before long decide of our own accord to give paper clothing a trial.

In anticipation our manufacturers, having no idea of allowing Germany to put it all over them, have not been idle. As a matter of fact, to meet a demand for cheap garments which cannot be manufactured of wool at present wartime prices, paper clothing of medium weight for men, is now being made in the United States and has already found some sale, although it is not sold, as in Germany, as "paper clothing," but under various trade names which are intended to, and do act as a sort of camouflage, for, as Barnum once remarked we like to be fooled.

To make it spruce or hemlock waste from the great north woods, is manufactured into paper yarn which is cut into strips and twisted into thread of various thicknesses for weaving.

One kind of this yarn, which when woven into cloth gives the appearance of an "all wool" garment, is made from paper which has been coated with a thick layer of cotton fleece, and subsequently cut into strips. In another process, the sheet of pulp is cut into strips of the required width by means of jets of water which play upon it and the paper is then ready for the spinning heads as soon as it leaves the paper machine, subsequent splitting not being necessary.

The very finest grade of paper thread is so delicate and fine that it is like silk in appearance. In all likelihood you are wearing paper or so-called "silk" socks made of it if you are a man, or stockings if a woman, unless perchance you pay a war price for real silk ones and are sure of your dealer's honesty. The silkworm caterpillar contains, in large vessels that occupy almost the whole of its body, a glutinous fluid. On its tailend, connected with these vessels, is a spinner provided with a number of small apertures through which the fluid passes. Immediately on exposure to the air it coagulates to thread, which is "raw silk."

The machine that converts raw paper into an artificial silk is, in a way, patterned after the caterpillar. A pure cellulose derived from wood pulp is held in a tank, and is forced out of the latter through many nozzles, which are glass tubes drawn so fine that the aperture of each is only one-eight-hundredth of a millimeter in diameter. Immediately hardening, the threads thus formed are caught and reeled just as natural silk is taken and reeled from silkworm cocoons. The fiber obtained by this means is as lustrous and beautiful as real silk, but less strong and elastic—for which reason the expedient is adopted of reinforcing it, in the weaving of fabrics, with an admixture of natural silk or of cotton.

Shearing sheep is work for an expert

Washing a wool clip before marketing

Apart from the suits, dresses, hosiery, "tear silk" underwear and other articles of paper clothing now on the market, there are also what we would least imagine could be made of paper, raincoats. Being almost wholly of paper with only a little cotton thread to reinforce the weave, they are remarkably cheap, handy and convenient. A surface glaze of some sort renders them quite waterproof and prevents the paper fabric from becoming soggy. This kind of garment does not last long, but it is worth what it costs, which is way below the regulation rubberized cloth out of which raincoats are usually made.

The largest single use of wood-pulp paper in the United States at present lies probably in the manufacture of rugs which is another big wool saving in these war times.

These rugs moreover have become popular recently, and may be purchased in almost any department store throughout the country. There are probably at least twenty-five paper, or as they are called, "fiber" rug factories in the United States and although their total output is not known, it is stated that one of them alone is turning out twenty-five tons of rugs daily. Most of the rugs are made entirely of wood-pulp paper; but there are several concerns that are putting out rugs that have a slight admixture of cotton or wool. There are several ways of obtaining the patterns in rugs. Probably the two commonest are by means of different colored yarns, and by stenciling. Both of these methods are comparatively simple and yield good results. When colored yarns are used the colors are added to the pulp before it is made into paper, and when the design is stenciled on this operation it is performed after the rug has been woven.

This coming summer the hat trade of the United States is preparing to put on the market, under various trade names, many hundreds of thousands of paper straw hats. Some of these hats are very attractive in appearance and have been woven to closely resemble the genuine Panama hat, but they can be sold for about one-third the price of the latter. Of course, they will not last like or stand the wear and tear of a real Panama, but they are much lighter than the regular straw hat most men wear, also much cooler. The Japs were the first to put paper hats on our market but the war and high cost of imported straws has brought our hat manufactures to them.

The Earth and Population

By Otto Klotz

RECENTLY there was published a monumental monograph of 466 pages, Appendix A., Vol. 1, Census of the Commonwealth of Australia, by G. H. Knibbs, C.M.G., F.S.S., F.R.A.S., entitled, "The Mathematical Theory of Population, of its Character and Fluctuation, and of the Factors which Influence Them." It is a work that marks a distinct epoch in census statistics. This brief note is concerned with deductions derived from the data of population and its rate of increase.

On page 31 of the above work we read: "This table shows, for the period 1804 to 1914, rates of annual increase ranging between 0.0015 and .0121 and averaging about 0.00864"; also that the world's population for 1914 was 1,649 millions. In an adjoining table we find the annual increase per 10,000 population to be for the quinquennium 1906-1911, for France 16 for England and Wales 104, for German Empire 136, for United States 182 for Commonwealth 203, and for Canada 298. The weighted average—including other countries not here given—is 115.9, which is equivalent to 1.156 per cent. From the above data we have selected the following for the subsequent computations and deductions: (a) the lowest annual increase between 1804 and 1914, .0015; (c) the average annual increase for that period .008640 (b) the annual increase for France for 1906-1911 .0016; and (d) the weighted average annual increase for 1906-1911, .001159.

The first query that suggests itself is—how far back would those four rates of increase respectively take us if we assume an ancestral pair? We have:

(a), $(1{\cdot}0015)^n = 8{\cdot}245 \times 10^8$, hence $n = 13{,}697$ years
(b), $(1{\cdot}0016)^n = 8{\cdot}245 \times 10^8$, " $n = 12{,}842$ "
(c), $(1{\cdot}00864)^n = 8{\cdot}245 \times 10^8$, " $n = 2{,}386$ "
(d), $(1{\cdot}01159)^n = 8{\cdot}245 \times 10^8$, " $n = 1{,}782$ "

These figures are interesting, for even the lowest rate of increase for the nineteenth century does not carry us back to the time required by geologist and anthropologist for the first evidence of the appearance of man. And the rate of increase for the quinquennium 1906-1911 would start the career of the first pair in A. D. 132! We conclude, therefore, that the rate of increase in the past ages has been less than the lowest of the past century, and very much less than our present rate. We shall presently see that our present rate must give us pause, unless we adopt the attitude, "What has posterity done for me?"

As we can readily look back on the world's written history for 2,000 years, we may well ask what will the population be in 1,000 in 2,000 years, hence?

Using the same data as before we have:

(a), $(1{\cdot}0015)^{1000} \times 16{\cdot}49 \times 10^8 = 7{\cdot}382 \times 10^9$, for 2000 years $= 3{\cdot}305 \times 10^{10}$
(b), $(1{\cdot}0016)^{1000} \times 16{\cdot}49 \times 10^8 = 8{\cdot}157 \times 10^9$ for 2000 years $= 4{\cdot}035 \times 10^{10}$
(c), $(1.00864)^{1000} \times 16{\cdot}49 \times 10^8 = 8{\cdot}983 \times 10^{12}$ for 2000 years $= 4{\cdot}893 \times 10^{16}$
(d), $(1{\cdot}01159)^{1000} \times 16{\cdot}49 \times 10^8 = 1{\cdot}666 \times 10^{14}$ for 2000 years $= 1{\cdot}684 \times 10^{19}$

This means that at the rate of increase of France (b), the population of the world would in a thousand years be about five times that at present, and in 2,000 years 25 times that of now. But see what would happen if the increase of 1906-1911 were maintained for a thousand years, a very short period even in the history of man, it would be 100,000 times the present population; and in 2,000 years, the stupendous figure of ten thousand million times the present population.

Don't imagine for a moment that this is juggling with figures, for they are sound deductions from the above data. Unless the data can be disproved the deductions stand.

Let us follow another line of reasoning. Goldsmith writes:

> "A time there was, ere England's grief began
> When every rood of ground maintain'd its man."

This is poetic license about the amount of land required. A fair estimate for the support of a person is taken at two acres, which would mean 320 persons to the square mile, about that of Germany, France being 191. Let us take roughly that one quarter of the surface of the earth is land, and that three-quarters of this, which is a high estimate, may ultimately be put under cultivation. Taking the radius of the earth as 3,960 miles, its surface is 5.4937×10^{15} square feet, hence the land ultimately available 1.03×10^{15} square feet, and this would support at the maximum 1.182×10^{10} people.

Hence we may ask in how many years will the present population reach the maximum possible 1.182×10^{10} that the earth can support?

Using the same data for rate of increase, we have:

(a), $(1{\cdot}0015)^n \times 16{\cdot}49 \times 10^8 = 1{\cdot}182 \times 10^{10}$, hence $n = 1{,}314$ years
(b), $(1{\cdot}0016)^n \times 16{\cdot}49 \times 10^8 = 1{\cdot}182 \times 10^{10}$, hence $n = 1{,}232$ years
(c), $(1{\cdot}00864)^n \times 16{\cdot}49 \times 10^8 = 1{\cdot}182 \times 10^{10}$, hence $n = 229$ years
(d), $(1{\cdot}01159)^n \times 16{\cdot}49 \times 10^8 = 1{\cdot}182 \times 10^{10}$, hence $n = 171$ years

These figures are simply alarming, showing at the present rate we are near the end of our tether. If we reduce the land required to support a person to an acre, it would only defer the evil day of the last figure by 60 years, and that of the second, based on the present rate of increase in France, by about 430 years.

Preachers of large families should take note. The multiplication table is inexorable. You can't fool it.

The antiquity of man upon the earth has been traced back ten thousand years and more. Let us project man 10,000 years into the future and see how he has multiplied, using again the former data:

(a), $(1{\cdot}0015)^{10000} \times 16{\cdot}49 \times 10^8 = 5{\cdot}33 \times 10^{15}$
(b), $(1{\cdot}0016)^{10000} \times 16{\cdot}49 \times 10^8 = 1{\cdot}45 \times 10^{16}$
(c), $(1{\cdot}00864)^{10000} \times 16{\cdot}49 \times 10^8 = 3{\cdot}79 \times 10^{46}$
(d), $(1{\cdot}01159)^{10000} \times 16{\cdot}49 \times 10^8 = 1{\cdot}83 \times 10^{69}$

These are such colossal figures that one utterly fails to comprehend their magnitude. However, we may use a device that will bring it somewhat home to us. We know the size of the earth and its specific gravity, hence we know its mass. Let us assume that the average mass of a person is 100 pounds. It follows that if we imagine the whole earth converted into people, their number would be 1.31×10^{25}. If there were that many people there wouldn't be any earth left, for man is but clay. Now look at the figures we had, say due to the average rate of increase of last century, namely .864 per cent, and we find the population resulting therefrom in 10,000 years is 3.79×10^{46}, *i. e.*, 3 followed by 23 noughts times the mass of the earth. There is no juggling with figures. Our industrial chemists may come to the relief of man in discovering synthetic food and thereby increase the availability of ground for population, but the absolute ground or surface available will soon put a bar even to this extension.

From all the preceding figures it is evident that we can't go on increasing at our present rate, and the day of reckoning is looming on the horizon with a certainty as great as that the sun will rise tomorrow, and this fact should not be ignored by men gifted with prevision. The only country at the present time that is reasonably living within its assets of land is France, for to double her population requires 433 years.

Our longest period deduced is under 14,000 years, which in the period of geological time reckoned at least at 100 million of years, is a mere bagatelle. Possibly the earth may be overwhelmed by another glacial period, and much of man and his work disappear before the advancing ice, later, thousands of years later, to evolve to his former self. Who knows? But we do know that the population can't go on increasing indefinitely at the present rate. The handwriting is on the wall.—From the *Journal of the Royal Astronomical Society of Canada.*

Oil From Grain Germs

WORD comes from Europe that a representative of the German War Committee for Oils and Fats recently addressed a meeting of the agriculturists and mill owners of the district of Solingen on the subject of the extraction of oil from the germ of grain. Although up to the present only 40 per cent of the German mills have made the necessary arrangements for the work, 5,000,000 litres of oil have been obtained from this source in nine months. The germ contains 10 to 12 per cent of oil, which it will be possible to utilize for the production of margarine. After the extraction of the oil, the residue of the germ yields a valuable albuminous food, which with the admixture of flour is utilized to produce rusks for the army, and has latterly been used also for the soldier's "morning drink." A still greater advantage resulting from the removal of the germ is the impossibility of the flour obtained from the grain becoming musty, since it is the fatty acids contained in the germ which cause decomposition. The flour is in no way inferior after the removal of the fatty substance; it bakes better, and the bread does not so easily turn mouldy. —*Rheinisch Westfälische Zeit., Bd. of Trade J.*

Salt Water Aquaria in the Home

By Ida M. Mellen

THE peculiar beauty and charm of animal and plant life in the sea arouses in our minds a natural craving to enjoy it close at hand. This is comparatively an easy task for residents of the coast, who may collect plants and animals for themselves and procure plenty of sea water; but for the inland aquarist it is a matter requiring more delicate care and closer concentration.

Salt water, with the animals and plants, can be shipped inland from the coast. Formulas for the preparation of artificial sea water have been devised, but we do not know of anyone who has succeeded with them.

That salts in water are not subject to evaporation, is illustrated by the eternal salinity of the seas, whose evaporation is replenished by water from the rivers that constantly flow into them; and though they acquire some additional salt from the rivers, their loss of that substance is so small that the new salt acquired really adds to their salinity. It is therefore quite practicable to compensate the loss through evaporation in the salt water aquarium with fresh water from the faucet once a week, and a watering can is very good for the purpose.

It is 75 years since the first salt water balanced aquarium was established in England, and many experimenters have been at work in the field since that time; but to secure a perfect balance of marine animals and plants, it is still difficult to suggest an infallible rule. As with fresh-water forms, the animals depend largely upon the oxygen thrown off by the plants, while the plants absorb the carbonic acid gas exhaled by the animals. The aquaria having capacities measured by the gallon are more satisfactory than those holding only quarts. There is small danger from an excess of plants, but too much animal life is certain to prove fatal.

All-glass aquaria are the best for salt water, and are the only kind used at the New York Aquarium for small marine balanced aquaria.

Marine collections of the happy family order are successfully maintained at the Aquarium in eight-gallon jars, with two kinds of plants and as many as eleven forms of animal life. The plants are the red alga (*Soleria chordalis*), sometimes attaching itself to rocks and again living free at the bottom, and the green sea-lettuce (*Ulva latissima*) buoyed with bits of cork to cover two-thirds of the surface and allowed to hang down ten inches from the top on the side of the jar nearest the light. The animals are:

Northern white coral (colonies ranging in size from 2 to 6 inches in diamater);
Brown anemones (3 or 4);
White anemones (3 or 4);
Tunicates (*Molgula*) (3 or 4);
Killifishes, 2 inches long (2 or 3);
Variegated minnows, 2 inches long (2 or 3);
Prawns, 1¼ inches long (2 or 3);
Young eels, 3 or 4 inches long (1 or 2);
Mud snails (*Nassa obsoleta*) (1 to 12);
Oyster (1);
Little-neck clam (*Venus mercenaria*) (1).

Warning has been given to the beginner by some aquarists to limit his animals, one to the gallon of water. It can be seen from the list just given that a gallon will accommodate more than one animal—even more than four—but in experiments with marine aquaria too much moderation cannot be urged at the start.

Sea-lettuce is absolutely essential for the balanced aquarium. Other plants may be used with it, as the red alga called flame weed (*Grinella americana*), and the dead, sun-dried hydroids such as *Sertularia argentea* and *S. pinnata*, make good ornamental effects.

Other animals that can be confined successfully in balanced aquaria are small mussels—say a quarter of an inch in length, rock barnacles, annelids (especially the tube dwellers), and very small crabs. Large crabs tear the plants and catch the fishes, but small mud and spider crabs, of one-half inch or so in diameter, are not only interesting (crabs being truly comical animals) but desirable, as they pick up scraps from the bottom. The small hermit crabs are especially good scavengers.

It is well to place an inch or two of fine pebbles, white sand, or bird gravel on the bottom of the jar, and a few stones must be added for the attachment of anemones and for the crabs to hide under. Care must be taken to wash the sand thoroughly. Bird gravel is very dirty and will ruin the aquarium if put in before cleansing.

Hermit crabs should be provided with empty shells of a suitable size so that when they outgrow the home they are living in and go house-hunting for a larger one, the new tenement will be at hand. They are pugnacious, and two will fight hard for the possession of a desired shell.

Little-neck clams and oysters, whose siphons are always busy, are valuable as clarifiers.

Snails that consume vegetation should be avoided. The periwinkles do not thrive as well in standing water, but no balanced aquarium is complete without a few mud snails (*Nassa obsoleta*). They do not harm the vegetation appreciably, preferring animal food, and besides being excellent scavengers, are always interesting to observe as they move about with their inquisitive siphons traveling a little ahead like an advance agent.

Young specimens of starfishes may be kept. They live on mollusks, however, and a supply of the mud snails is necessary for them. It would not be possible to keep an oyster, clam, or any other mollusk alive in the jar with a starfish, and at best the starfishes are not long-lived in captivity.

Probably the most attractive of all small fishes is the sea horse; and the general desire to own one is so great that people even inquire if they could not keep one in the same jar with their goldfishes! The little creature is difficult to provide for, except with running sea water and salt water *Gammarus*—the minute shrimp that infests the sea-lettuce. Some aquarists have succeeded in maintaining sea horses for a number of months in balanced aquaria by feeding them with fresh chopped prawn on the end of a stick, which the little fish soon grows tame enough to take.

A New York dealer in aquaria and aquarium supplies, who sells sea horses, tells us that he feeds them on daphnia—the common water flea of the ponds—by taking the sea horses out of the salt water and the daphnia out of the fresh water, and putting them all into brackish water one-third salt and two-thirds fresh. Within an hour the sea horses are replaced in salt water, and this process he repeats each day. Fresh-water shrimps are a welcome substitute for the salt water variety, and will live several hours in sea water.

During a shortage of *Gammarus*, we have succeeded in enticing some of the sea horses to eat the fresh water worm *Tubifex*, which will live for half an hour in salt water, and some were also coaxed to partake of enchytrae. One of the Chicago department stores maintains an aquarium and has succeeded in keeping five sea horses alive since last summer by feeding them on the new-born young of small, fresh-water viviparous fishes. These little tropical fishes are well known to aquarists, and include Guppyi or rainbow fish, Helleri or swordtails, Gambusia, etc.

Other fishes, also crabs and prawns, annoy the sea horses, but it is possible to keep anemones, barnacles, oysters and clams in the same jar with them.

The salt water aquarium requires strong light, but should have very little direct sunlight,—none in the summer and not over an hour or two a day in winter. The most useful cover is one made of glass of the same diameter as the jar, with bits of cork glued to its edges at several places in such wise as to allow it, when set on the jar, to rest on the corks a quarter of an inch above the top of the aquarium. Such a cover prevents the escape of crabs, snails, etc., retards evaporation, and keeps out dust.

Animals in all balanced aquaria at the New York Aquarium are fed three times a week with macerated clam. Care is taken to drop small pieces from the end of a stick or long wooden forceps upon the tentacles of the corals and anemones, which then may be seen to carry the food to their mouths. All food not eaten within a few hours is carefully siphoned off with a glass tube.

For the inland aquarium, dried shrimp, desiccated cod fish after the salt has been soaked out of it, fresh-water mussels, or fresh fish, finely chopped, would serve. Fresh fish, however, is oily, and even an expert aquarist must take unusual care in using it.

A bit of wood fastened at the end of a stick and covered with felt or cheesecloth, is useful to clean the inside of the glass. In the matter of impurities in the water, an ounce of prevention is worth many a pound of cure; particularly in the inland marine aquarium. The speedy removal of dying plants and dead animals is very essential. For this, a long wooden forceps is a convenient tool. Some aquarists advocate a bit of charcoal placed under the rocks as a clarifier.

During a succession of gray days, the water may be aerated by lifting out a dipper full at a time and letting it fall back from a height of several inches. When the sand appears dirty, it is well to siphon off the bottom with a rubber tube until about four inches of the water have been drawn. This can be used again by filtering through four or five thicknesses of cheesecloth, or letting it seep through a sponge placed in the bottom hole of a watering can. The same method may be employed if the water appears a trifle cloudy.

What is only difficult, may appear to the novice impossible. He must not be discouraged if his first efforts fail, however, but remember that "Patience and perseverance overcome all obstacles," and, as a wise lady once remarked, the only difference between the difficult and the impossible is that the impossible takes a little longer time.—*Bulletin of the N. Y. Zoological Society.*

Limitations of Our Supply of Petroleum

WHAT shall we do when our supplies become depleted? Although this country has large known reserves of petroleum, these supplies are limited. At our present rate of consumption our estimated supplies are sufficient to meet our present needs for a comparatively short period, conservatively estimated to be from 25 to 30 years, taking no account of the increasing demand for petroleum and its products. This estimate not only includes the oil fields already known and developed, but makes liberal allowances for undiscovered fields in prospective oil territories. It should not be thought that our petroleum supply at the end of that period will be cut off abruptly, for the wells will continue to produce through a declining output for many years. On the other hand, the shortage of petroleum is beginning to be felt now. A good measure of the accuracy of these estimates, which were made more than a year ago by the Department of the Interior, is the result of the search for oil the past year. Owing to the demand for crude oil, more territory was prospected and more wells were drilled in search of petroleum in the Mid-Continent field than in any previous year. During the year 1916 there were approximately 15,000 wells drilled in that field, as compared with 6,000 wells drilled in 1915, yet the production today will not equal that of two years ago, in 1915, nor have any large new oil fields been developed.

What effort have we made to conserve this supply and to utilize it to its greatest advantage? We have made little effort until very recently to do these things. We have been wasteful, careless, and recklessly ignorant. We have abandoned oil fields while a large part of the oil was still in the ground. We have allowed tremendous quantities of gas to waste in the air. We have let water into the oil sands, ruining areas that should have produced hundreds of thousands of barrels of oil. We lacked the knowledge to properly produce one needed product without overproducing products for which we have little need. We have used the most valuable parts of the oil for purposes to which the cheapest should have been devoted. For many years the gasoline fractions were practically a waste product during our quest for kerosene; with the development of the internal-combustion engine the kerosene is now almost a waste product in our strenuous efforts to increase the yield of lighter distillates.

This country is producing about two-thirds of the world's output of crude petroleum and has produced approximately 2,750,000,000 barrels since the drilling of the first oil well by Col. Drake in 1859. Our future supply from both proved and prospective oil fields, based on geological possibilities, is estimated to be approximately 7,402,000,000 barrels, which will last us only about 25 years at our present rate of consumption. We are exporting 20 per cent of our production, using approximately 25 per cent as fuel under boilers, and of the remainder probably one-fourth is wastefully utilized. Thus 70 per cent in all is being used in a manner that must be considered anything but conservative for so valuable and so scarce a product.

As an example of wasteful utilization, a large proportion of our artificial gas is made from petroleum, notwithstanding the fact that coal has been and is used for this purpose, and would be used altogether except for the reason that the gas manufacturer is able to buy petroleum cheaper. At the present rate of production it is estimated that our coal supply is adequate for many centuries. Clearly we should not use our petroleum for fuel under boilers or for gas manufacture, or in any way to compete with coal, when the oil supply is so limited.—From the *Yearbook of the Bureau of Mines.*

Soluble Nitrogenous Substances as an Index of the Baking Value of Flour

THE most favorable proportion of soluble nitrogen with respect to total nitrogen in flour is about 16 to 17 per cent. Flours with this proportion of soluble nitrogen absorb water well and the dough has a good plasticity. If the proportion of soluble nitrogen rises or falls too much the flour is likely to show bad baking qualities. If the total nitrogen rises too much the flour is worked with great difficulty.—Note in *Jour. Soc. Chem. Ind.*

Boiler Corrosion*

By Basil G. McLellan

THIS paper deals with a case of boiler corrosion which I think may be typical of many others, and with an attempt to discover the causes of this corrosion.

A range of Lancashire boilers were fed prior to 1910 with town water with a total hardness of 17 to 23 parts per 100,000, of which 13 to 17 was temporary and the remainder permanent. A certain amount of oil had access to the feed water from waste steam, etc. Under these conditions a thin layer of hard scale accumulated in the boilers and this had to be chipped off periodically. There was no corrosion. The source of the feed water was changed, and well water, having 74 parts per 100,000 total hardness, softened down by lime and soda treatment to 7 or 8 parts, was used. This water contained an excess of chemicals just sufficient to reduce the hardness to zero; precautions were also taken to eliminate all traces of oil from the feed water. The result was freedom from corrosion and from scale in the boilers, with a moderately soft scale in the pre-heaters and economizers. To eliminate this scale, it was decided to reduce the hardness by using a greater excess of chemicals. This was done, and the softener was run for three weeks, producing a water with a hardness of 3 to 4 parts per 100,000 with an excess of chemicals equal to 11 or 12 parts per 100,000. This naturally brought about an accumulation of alkalis in the boiler. The effect of this alteration, which was observed the next time the boilers were opened, was a reduction of scale in the pre-heaters and economizers, no scale in the boilers, and the first appearance of corrosion there in the form of pitting. Even though the softening conditions were readjusted so as to eliminate the excess of alkali, the effect was similar to that formerly observed, but corrosion continued in the boilers.

This corrosion was observed at every inspection for several years. Sometimes it had gone on only to a moderate extent, and sometimes fairly rapidly. It was usually found on the furnace tubes and on the shell near the tubes, and later it was found in the lower part of the upper drums of water-tube boilers which had been installed.

This corrosion was due to oxidation, and I am of the opinion that the period of strong causticity removed from the boiler shell a thin layer of oil residue which for years had acted as a protective coating; the surface of the plates was thus rendered clean, active, and open to attack.

The opinions of experts were evenly balanced as to the cause, and these were:

1. Oxidation by dissolved oxygen in the feed water.
2. Electrolytic action.

Remedial measures were proposed, or suggested themselves to us, for overcoming either of these corrosive influences, but it was necessary to determine which was causing the trouble.

At that time I was of the opinion that dissolved oxygen was not the cause of the corrosion, and that opinion was based very largely on the work of Professor Cobb (see this J., 1914, 403). If I interpret his results aright, corrosion by dissolved oxygen would take place near where the air was first liberated from solution in the water, namely, in the pre-heater tubes, and would certainly not extend beyond the batteries of economizers, where ample provision is made for blowing off the air which collects in them.

It is obviously difficult to devise experiments on a plant scale to decide a point like this, so an eliminating experiment on a laboratory scale was suggested, namely, to remove all dissolved oxygen and try whether corrosion took place in its absence. The experiment was carried out as follows:

A number of similar bars of metal were cut from the same piece of boiler plate; these were machined up and polished. Two of them were suspended by means of iron wires in a bell jar; the wires passed through a rubber stopper, through which a three-way stoppered tube passed. The electrolytes used were placed in a large evaporating basin and boiled until free from dissolved oxygen, tests being made (by Winkler's method) from time to time as boiling proceeded. The bell jar was then supported over the boiling liquid and filled with hydrogen through the stoppered tube. It was then lowered so as to be sealed by the electrolyte and hydrogen was passed in until all the oxygen was removed. The bell jar was then lowered, allowing hydrogen to escape, until about one half of each electrode was immersed. In a few moments the boiling was stopped, and air was excluded from the surface of the electrolyte outside the bell jar by covering it with a layer of mineral oil. During cooling the level inside and outside the bell jar was kept constant by adjusting the volume of hydrogen gas inside. The terminals were connected up to a millivolt meter, by means of which the difference of potential could be noted. It was thus possible to operate in absence of free oxygen.

The trials lasted for some days. The electrolyte was heated during several days, but the greater part of the time it was cold.

Trials were made with softened water, with boiler water which had become concentrated, and with distilled water.

Softened water.—The technical analysis of this was as follows (in part per 100,000 expressed as $CaCO_3$):—Hardness 8.7; alkalinity, to methyl orange 12.7, to phenolphthalein 9.7; (OH) alkalinity after removing carbonates 3.6. The water still contained 0.32 c.c. of oxygen per liter. The potential difference between the two electrodes varied up to 18 millivolts, first one electrode and then the other being at the higher potential; slight vibration of either was sufficient to alter its polarity, tending to make it electro-negative.

The trial lasted eight days; a considerable amount of rust settled in the basin, and the bars showed distinct signs of corrosion.

The electrolyte, at the end of the trial, contained 3.0 c.c. of oxygen per liter, the increase having been produced electrolytically.

Concentrated boiler water.—This was a very concentrated liquor, resulting from under-softened water. The following figures show its composition:

Parts per 100,000 as $CaCO_3$.

Total alkalinity	212·6	Total hardness	35·5
Chlorides	305·7	Lime hardness	23·3
Sulphates	1390·3	Magnesia hardness..	12·2
		Alkalis (diff.)	2233·1
Total acids	1908·6	Total bases	2268·6

The water was entirely free from dissolved oxygen. The potential difference was greater on the average than with the softened water.

The trial lasted 26 days, and the corrosion was very marked. At the end of the trial the electrolyte contained 0.9 c.c. of dissolved oxygen.

Distilled water.—This trial was run to ascertain the effect of a very soft water. The water contained 0.28 c.c. of oxygen per liter. The potential difference throughout the run of 15 days was small, not exceeding 5 millivolts. The plates indicated some corrosion, which was confirmed by the deposit of rust in the basin. At the end of the trial the electrolyte contained 2.6 c.c. of oxygen per liter.

The conclusion to be drawn from these tests is that even the absence of dissolved oxygen is no guarantee that corrosion of this order will not take place. That the corrosion referred to in the boilers was caused solely by electrolytic action is not definitely proved, but the evidence is fairly strong.

Some years ago Cumberland devised an electrical apparatus for overcoming electrolytic corrosion. Insulated iron rods are inserted into the boiler, heater, or whatever piece of plant is to be protected. Current, generated externally, sufficient to overcome any local potential differences is passed through the system so as to make these insulated rods the anodes. These corrode away, and are renewed from time to time. The electro-negative surfaces are kept free from scale and corrosion, and in cases where this plant has been installed in scaly boilers, the old scale has been removed, possibly by the formation of hydrogen below the scale.

The process has, I understand, been extensively installed on large ocean liners and also in factories. I have no direct experience of the process, but it seems to me to be sound. A reversal of current would be disastrous.

It is sometimes recommended to coat the inside of boilers with a protective paint as a cure for corrosion. Graphite in a volatile carrier is frequently used. If the corrosion is due solely to dissolved oxygen, this may be efficient, but unless the coating is absolutely perfect—which it never can be in practice—it is difficult to see how it can do otherwise than aid corrosion, graphite being electro-negative to iron.

Finally, we will look for a moment into certain conditions which have been observed to aid or retard boiler corrosion. It is frequently stated that small quantities of caustic soda in feed waters have little effect on the corrosive power, while similar quantities of sodium carbonate stimulate corrosion. This may be regarded as a rough-and-ready statement, but it is the experience of those who have to handle boilers. If we examine these statements in the light of the so-called and commonly accepted "CO_2-theory" and from the point of view of electrolytic action, some light may be shed on them.

The "CO_2-theory" is expressed as two equations:

$$Fe+H_2O+CO_2=FeCO_3+H_2$$
$$4FeCO_3+O_2+6H_2O=2Fe_2(OH)_6+4CO_2$$

and shows the mode of action of water containing oxygen and CO_2 on iron. At boiler temperatures the latter equation might be:

$$3FeCO_3+O=Fe_3O_4+3CO_2.$$

Now I think it is quite conceivable that an action of this kind can take place in a feed water which is devoid of free oxygen and carbon dioxide if it contains an excess of sodium carbonate. At the high temperatures in the boiler the sodium carbonate is partly dissociated and carbon dioxide is set free to form ferrous carbonate as in the first part of the CO_2-theory. We have now to consider two electrodes, one of clean iron and the other of ferrous carbonate. I have no evidence to show which of these is electro-positive and which electro-negative, but there is almost certainly a considerable potential difference which will result in corrosion.

If there is sufficient excess of sodium hydroxide in the feed water, the dissociation will not be effective, and corrosion of this kind will not take place.

*Read before the Yorkshire Section of the Society of Chemical Industry and reported in the Journal of the Society.

Rare Metals in the United States and Their Alloys

THE metallurgy of molybdenum has been little understood and the methods used have been expensive. Two types of ore are commonly found in the West, namely, molybdenite or molybdenum sulphide, and wulfenite or lead molybdate. The former frequently carries impurities, mainly copper, which must be separated from the molybdenum in order that the latter can be sold. Wulfenite contains not only lead, but sometimes gold, vanadium, and other metals, and therefore its metallurgy is somewhat complex, as any really successful method should obtain all of the valuable substances present.

General problems in connection with uranium, vanadium, tungsten, molybdenum, and other rare metals will be investigated, particularly as regards the ore supply, methods of concentration, and ore treatment. It has already been pointed out that a small quantity of copper in molybdenum ore is sufficient to prevent the sale of such ore, and the same thing applies to certain impurities in tungsten ores. The question of cheap and efficient methods for the elimination of such impurities would put on the market ore that at present can not be sold to advantage.

Many of the rare metals form alloys, both among themselves and with the commoner metals, and the alloys have a great commercial value. For example, tungsten when added to steel gives to the steel certain qualities that cause the products to be in great demand for the manufacture of cutting tools for lathes, etc. Recently uranium has been successfully substituted for a large part of the tungsten in tool steel to the seeming improvement of the product and it is reported that uranium steel is showing remarkable endurance when used for the liners of cannon. Some alloys of the rare metals containing no iron at all have shown interesting properties, and much research in regard to these and other alloys should be undertaken.

The European war, which has cut off many of our supplies heretofore imported, has aroused much interest in the conservation of our minor metal resources. The development and application of processes for saving the low-grade rarer minerals offer special inducements, and as all investigations carried on are made especially with the view of preventing waste and utilizing low-grade products, this work should be of great benefit to the mining industry.—*Yearbook of the U. S. Bureau of Mines for 1916.*

Gasoline from Casing-Head Gas

CASING-HEAD gasoline is made by two different processes, the compression process and the absorption process. In the compression process the wet gas is compressed by large machines to a pressure between 200 and 300 pounds to the square inch. The compressed product is then cooled and the "wet" parts of the gas condensed. The high-gravity product is then mixed with low-gravity distillates and kerosene, which can not be utilized by themselves in automobile engines. However, the addition of the light-gravity gasoline gives the resulting mixture a volatility sufficient to permit ready combustion in automobile motors.

The absorption process of making gasoline may be used for casing-head gas or for gas that does not occur with the oil. This process is based upon the fact that when the wet parts of the gas are forced through certain kinds of oil used for absorption, the oil absorbs the light particles of gasoline carried by the gas. These are later recovered from the oil by heating it, the gasoline being driven off and the high-gravity product being condensed. The product of the absorbers is blended with a heavier distillate as is the product from compressing casing-head gas.—*Yearbook of the U. S. Bureau of Mines for 1916.*

Air Pumps and Condensers in Steam Engineering*

THE advantage of using steam jets in series with an ordinary reciprocating air pump has long been recognized in power station practice, where, since the advent of the turbine, the desideratum has been the maintenance of the highest possible vacuum consistent with the available supply of cooling water. No doubt, by the exercise of extreme care, in reducing to a minimum all air leakage, even that through mere pin holes, nearly as good results can be obtained without a steam jet as with it, provided, of course, that the steam plant is of the turbined type. The maintenance of this exceptionally high standard of airtightness demands, however, such constant vigilance on the part of the station staff, as to have made most engineers consider it preferable to install the steam jet, with which high vacuum can be secured without the necessity of such exceptional and unceasing care.

Of course, in the case of a reciprocator the permanent maintenance of a really high vacuum is almost impracticable without the use of the jet, but admittedly, the disadvantages attaching to a poor vacuum are also less serious than they are when steam turbines constitute the power plant. This arises because the reciprocating engine is incapable of utilizing the "toe of the diagram." In fact, the recognized standard vacuum in the case of Lancashire mill engines tends, in practice, to be rather below than above 24 in., and whilst a 28-in. vacuum is not infrequently specified for cargo boat engines on trial, few sea-going engineers attempt to maintain this standard in actual service, where such a figure as 25 in. is by no means uncommon.

A new application of the steam jet to vacuum production has recently been suggested by Mr. D. B. Morison. As the result of an extended investigation, he has been brought to the conclusion that great as is the value of the steam jet for the production of a good vacuum, it has at least equal advantages when the conditions are such that a poor vacuum meets the needs of the case. From Mr. Morison's experiments it appears that if a 25-in. or 26-in. vacuum will satisfy requirements, this can be obtained more cheaply and maintained more certainly by the use of auxiliary steam jets than in any other way.

A bad vacuum in a condenser, if not due to dirty tubes or hot cooling water, implies that much of the tubing is air jacketed and correspondingly inefficient. With a clean condenser, and with an air leakage reduced to a minimum, the rate of heat transfer may approach the figure of 1,000 B.Th.U. per square foot of cooling surface per hour and per degree of temperature difference between the steam and the cooling water. Indeed, under experimental conditions, this figure may be very materially increased. No very large amount of air leakage will, however, suffice to reduce the rate of heat flow from steam to cooling water by 60 per cent to 70 per cent.

It is impracticable in the commercial operation of reciprocating engines to prevent air leakage, and as a consequence much of the tubing in the condenser becomes seriously ineffective. The rate of heat flow is no doubt satisfactory in the case of the upper nests of tubing, which receive the first rush of the steam. As the steam enters the condenser the proportion of air to steam is small, but as the mixture of gas and vapor passes on towards the air pump inlet this proportion becomes higher and higher, so that the air may ultimately form the preponderating constituent. Air is a most excellent non-conductor. As the mixture passes over the tubes the steam, as it condenses, drops away as water, but the air remains behind, jacketing the tube and hindering the access of further molecules of steam to the cooling surface. The lower rows of tubes in a reciprocating engine condenser become accordingly singularly ineffective.

The question naturally arises, as to why, this being so, they cannot be abolished, retaining merely the upper and more efficient rows. The answer lies in the fact that the air pumps can only remove a certain volume of air per minute, equal, at best, to their gross piston displacement. The volume of the air to be abstracted depends both on its temperature and pressure. If the lower tubing be removed as suggested, the air will be delivered to the pumps at a higher temperature. Hence, to remove the same weight per minute, either the piston displacement must be increased or the air must be delivered to the pump at a higher pressure which will, of course, involve a worse vacuum in the condenser. Moreover, the higher pressure of the air inside the condenser will render it an even more effective blanket than before. A limit is thus set to the possibility of removing the ineffective tubing.

Here is to be found the advantage of the steam jet. Suppose the lower ineffective tubes to be removed, then, as pointed out, as the air is hotter, it must reach the pump at a higher pressure than before if the weight of it delivered per minute is to remain unchanged. With no aid from steam jets this higher pressure in the pump would involve a worse vacuum in the condenser. By interposing steam jets between the condenser and the pump, these jets, which, as is well known, have a great volumetric capacity, compress the air into the pump suctions, so that a large weight of air can be abstracted with a very moderate pump displacement. The great advantage of this in the present shortage of brass and other copper alloys lies in the fact that the amount of cooling surface in the condenser can be reduced 20 per cent to 25 per cent without loss of vacuum and the air pumps may also be much smaller than is called for in ordinary standard practice. There is thus a direct and material saving in capital costs, and also, of course, in the time needed for constructing the condenser and its

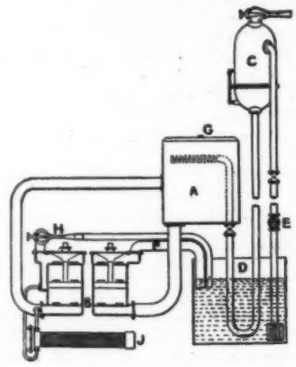
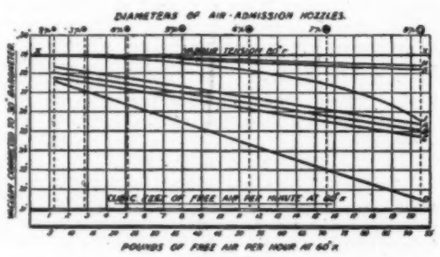


Fig. 1

auxiliaries. These considerations would, of themselves, be sufficient to justify the extensive adoption of the system at the present crisis. The experiments carried out, with Mr. Morison's plant, on behalf of the North East Coast Institution of Engineers and Shipbuilders[1] show, however, that over and above the gains under this head the running expenses are actually lower than with the usual system. Thus suppose that with the ordinary system steam-driven air pumps of the best type are used, having say a consumption represented by 100; then, if the Morison system be adopted, allowing the condenser surface to be cut down by 25 per cent, the combined consumption of the air pumps and the jets will be represented by perhaps 80. This way of stating the facts indeed rather underestimates the gain, since it has been found that the jets can be worked perfectly well with exhaust steam from the auxiliaries which would otherwise be for the most part wasted. Moreover, the feed is delivered to the hot well at a higher temperature than would be practicable were it necessary to keep the condenser



[Fig. 2

at a temperature low enough for the air to be dealt with by ordinary air pumps without prior compression by the jets.

The experiments on the Morison apparatus were carried out for the North East Coast Institution by Messrs. E. L. Orde, C. W. Cairns, and Dr. J. Morrow. The plant, which is depicted diagrammatically in Fig. 1, consisted of a receiver A, 4 ft. 3 in. in diameter by 4 ft. high, which represented the condenser, and was built of steel plates. Water drawn up by suction from a tank D, representing the usual hot well was sprayed into this vessel near its top, and was withdrawn at the bottom by the pumps being returned by them to the hot well. As very large quantities of air were delivered with the condensate a de-aerator C was interposed between the hot well and the receiver, as indicated. A vacuum of 25 in. was maintained in this de-aerator by means of a steam jet. A number of gaged orifices, ranging from 2 mm. to 8 mm. in diameter were fitted, through air which could be admitted to the receiver. The 2 mm. orifice, as indicated in Fig. 2, discharged about 6 lb. of air per hour, and the 8 mm. orifice about 93 lb. of air per hour, a figure which would represent a truly enormous leak. In power station practice, for example, it is recognized that the weight of air entering the condenser per hour should not exceed 4 lb. per 10,000 lb. of feed.

In this figure the line XX shows the vacuum which would have been obtained in the complete absence of air. The upper lines H and G show how closely this ideal is approached when steam jets are used to assist the air pumps. The curve H was obtained when the "condensate" was about 10,000 lb. per hour, and G when it was 60,000 lb. per hour. The curves A, B, C, were obtained with the air pumps operating alone, the steam jet and its accessories being removed. The curve J shows the vacuum obtained when the steam jet was used, but the air pump capacity halved. It should be compared with D, which shows the results obtained without the steam jet, but with half the air pump out of action.

The first series of trials were made with ordinary reciprocating air pumps, having two barrels, 20 in. in diameter by 15 in. stroke, and driven by steam. The arrangement was such that both barrels could be worked either on the ordinary wet system, or with one barrel wet and one acting as a dry air pump. In these tests the steam jet apparatus indicated in Fig. 1 was of course out of action. It was found that with the 8 mm. nozzle open a vacuum of 26.2 in. could be maintained with the air pumps acting alone, the steam consumption being 1,420 lb. per hour. Using a steam jet taking 430 lb. of steam per hour, and running the air pumps at such a rate that their consumption was 940 lb. per hour, making a total of 1,370 per hour, the vacuum with the same air orifice open was 28.22 in. Hence the reduction in steam consumption was accompanied by an improvement of 2 in. in the vacuum. If this higher vacuum were not required, the steam consumption could obviously have been still further reduced. In this series of experiments the jets were fed with steam at 70 lb. gage pressure. In another set of trials steam at a pressure of from 3 lb. to 26 lb. (gage) pressure was used for the jets. In this case the jets were arranged in series. In the same conditions as already noted above, a vacuum of 27.55 in. was maintained with the 8 mm. orifice open, the total steam consumption for jets and pumps being 1,700 lb. per hour. With the 7 mm. orifice open (which passed in about 71 lb. of air per hour), a vacuum of 26 in. was maintained with a total consumption of 1,320 lb. per hour, of which two-thirds was steam at 30 lb. pressure. The air pumps acting alone consumed under the same conditions 1,420 lb. per hour, the vacuum being 26.65 in. In this case, of course, the whole of the steam used was high pressure steam. In these particular tests the air leakage was abnormally high. With more normal conditions of operation, however, the advantage of the Morison system was still manifest. Thus with the 3 mm. nozzle open, which passed about 13 lb. of air per hour, the air pumps acting alone, consumed 780 lb. of steam per hour in maintaining a vacuum of 27.4 in. With the same air nozzle opening the combination of low pressure jets and air pumps gave a vacuum 28.80 in., with a total consumption of 740 lb. of steam per hour, of which but 280 lb. were used for the pumps. The pressure at the jets in this test was respectively 7 lb. and 9 lb. per in. gage.

The report will well repay careful study, and affords substantial grounds for anticipating important changes in the construction of condensing plant for cargo steamers.

*Engineering.

[1]First Report to the Council of the North East Coast Institution of Engineers and Shipbuilders on Certain Methods of Producing Vacuum. By Edwin J. Orde, C. Waldie Cairns, M.Sc., J. Morrow, M.Sc., D. Eng. Published by the Institution, Newcastle-on-Tyne Price, 10s. 6d.

Fractionating Apparatus for Gasoline and Other Volatile Substances

THE apparatus consists of six flasks having wide necks and each provided with a small reflux condenser connected with a side tube at the top of the neck. Each neck is closed by a stopper through which passes a tube closed at the bottom and extending into the neck; suitable tubes connect these tubes in series. The flasks contain petroleum fractions having the following b. pts. respectively:—above 150°, 130°—150°, 110°—130°, 90°—110°, 70°—90°, 50°—70°, and below 50° C. The flasks are heated by separate burners so that the tubes in the necks are surrounded by vapors at the temperatures mentioned. The gasoline under examination is admitted, drop by drop, into the first tube and the more volatile portion is at once driven over into the second and succeeding tubes, so that fractions of decreasing b. pts. collect in the series of tubes. Means are provided for drawing off these fractions and for condensing the very volatile vapors which escape from the last tube of the series.—Note in *Jour. Soc. Chem. Ind.* on an article by E. HILDT in *Comptes Rend.*

Notes on the Protection of Eyesight*

By W. S. Andrews
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It is commonly known that visible light is a sensation produced in our eyes by vibrations or waves in the ether of space. These waves are so exceedingly minute that their length from crest to crest is generally expressed in "Angstroem Units," each unit being one ten-millionth part of a millimeter.

Ether waves that measure 7,600 to 6,500 A. u. from crest to crest are manifested to the eye as red light, and those that measure 4,200 to 3,900 A. u. are seen as violet light. Between these extreme limits of wave-lengths we find visible light of all the colors in the rainbow, the blending together of which in daylight produces what is known as white light, being thus named because it shows all objects in their true colors. Light that is artificially produced by flame or incandescence usually contains a preponderance of red and yellow rays, so that it does not show colors as correctly as does daylight.

Just as there are no sharp lines of definition between the different colored bands in the rainbow, so also do visible and invisible radiations gradually merge one into the other; and for convenience it may be roughly stated that the average human eye perceives visible light between wave-lengths from 7,600 to 3,900 A. u.

Ether waves that measure more than 7,600 A. u. (up to about 3,000,000 A. u.) constitute the infra-red or heat rays, and those that measure less than 3,900 A. u. (down to about 500 A. u.) are known as ultra-violet rays.

We have, therefore, three divisions of radiation under consideration that are manifested respectively as infra-red or heat rays, visible light, and ultra-violet rays, the first and last being invisible. All of these radiations which have a common origin in the almost unthinkably minute waves in the universal ether, differ from each other only in wave-lengths and frequency, but yet they affect our senses very diversely. Let us, therefore, proceed to examine their physiological effects with special reference to safety of eyesight.

INFRA-RED OR HEAT RAYS

The greater part of the radiation from the sun consists of invisible heat rays; but as these are also accompanied by very bright light rays, the direct influence of which the eye naturally avoids, no special protection is required excepting under unusual conditions.

In various mechanical operations, however, such as in furnace work, iron welding with the electric arc, etc., the operator should carefully guard his eyes against heat rays by some appropriate shield. Various kinds of glasses are sold for this purpose, some of which are wonderfully efficient in absorbing heat rays while they are fairly transparent to visible light. Dark mica also makes a very efficient screen for heat rays but it also absorbs a large percentage of light. Ordinary clear glass absorbs some amount of heat, but it is not sufficient protection against any intense source.

TABLE I

Material of Screen	Thickness in Inches	Percentage Heat Absorbed
Clear white mica	0.004	19
Clear window glass	0.102	26
Flashed ruby glass	0.097	31
Blue glass	0.093	57
Emerald green glass	0.100	64
Dark mica	0.004	67
Corning G124J glass	0.095	90

Table I shows the heat absorption of different glasses and mica as based on recent tests. However, owing to the fact that glass varies very much in its chemical constituents, as well as in its depth of coloration, the figures presented can only represent general approximate results. The thickness of the material also naturally influences its absorptive power, although not in a direct ratio. It is worthy of note that dark mica only 4/1000 of an inch thick absorbs heat rays better than green glass that is $\frac{1}{10}$ of an inch thick. The source of heat used in this test was a 200-watt gas-filled tungsten lamp operated at a little below normal voltage.

As the surface of our bodies is sensitive to heat rays, we are thereby warned; but it is to be remembered that the delicate tissues of the eye are more liable to be injured by these rays than the coarser tissues of our skin, and common prudence will dictate a reasonable amount of precaution, when the eyes are exposed to heat rays, especially if these rays feel uncomfortable to the skin.

Long continued proximity of the eyes to even moderate sources of heat may easily produce bad effects by cumulative action. In this way, glass workers who operate with unprotected eyes near to their gas jets are subject to cataract which might be entirely prevented by the use of protecting goggles.

*From *The General Electric Review.*

VISIBLE LIGHT

There are three very important features in connection with visible light that should be carefully avoided to preserve good eye sight; viz., intense glare, insufficient light and flickering. A very bright light naturally exerts a great strain on the delicate muscles of the eye, which endeavor to contract the pupil abnormally to shut out as much as possible of the glare, and under this condition the eye soon gives warning of fatigue. Also, reading or working in a dim light such as twilight can only be done at a risk of injury, as in this case the muscles of the eye are strained to expand the pupils to the fullest possible extent. With a flickering light these effects are greatly aggravated, as the involuntary muscles of the eye try to keep pace automatically with the variations in brightness, and eye strain of more or less severity ensues. A flickering light above all things should be avoided in reading, or in fact in doing any work requiring the continuous use of the eye.

In mechanical operations that involve the use of high temperatures and consequent intense glare, suitably colored glasses should always be worn. Many different kinds of glasses have been put on the market by manufacturers; and, in selecting from these, it should be borne in mind that the particular shade and depth of coloring which gives the *clearest definition combined with sufficient obscuration of glare* should be chosen. The selection must therefore be necessarily governed by the character of the work and the intensity of the light; but as the eye is more sensitive to yellow-green light than to other combinations, it will generally be found that glasses inclined to this shade will give the best results. When used for protection against very bright light, such as that produced in electric arc welding or in the manipulation of melted quartz, etc., a smoky effect is usually introduced into the glass to help the absorption. Certain tints of dark mica have been found particularly effective in this respect, and this material is all the more valuable on account of its efficiency in absorbing heat rays as previously noted.

Special optical glasses are now commonly employed in goggles that are used for small work, but in heavy welding operations with large current it is necessary to protect the entire face and neck from the intense radiation produced; and in this case masks made of light vulcanized card or fiber are employed, having comparatively large openings through which to see the work. The expense of fitting these large apertures with special optical glasses is considerable, so combinations of ruby and green glass plates are in common use and have proved to be an economical and effective substitute. Combinations of ruby and blue glass have also been tried for this purpose, but better definition and general good results are to be attained with the red green combinations. If dark mica can be procured of a proper size and uniform in tint and thickness, it would constitute a very effective material for use in masks; but for mechanical reasons, it would necessarily require facing on both sides with sheets of clear glass.

In standardizing glasses for various operations, it is to be emphasized that the main features to be considered are the attainment of a maximum of definition with a sufficient diminution of glare, and certain color combinations fill these requirements, but the particular depth of tint may perhaps be best decided by the operator, as there is a considerable individual difference in acuteness of vision, thus making it impossible to lay down an exact standard for general use under definite conditions.

ULTRA-VIOLET RAYS

These are by far the most dangerous of all radiations to the eye, and the more so because they are not only invisible but also because we are unprovided by nature with any organ or sense for detecting them, so we know of them only by their effects. Fortunately, the most deleterious of the ultra-violet rays, *i. e.*, those rays having a wave-length of about 3,400 A. u. and less, are completely absorbed by a moderate thickness of almost any ordinary kind of glass, so that, when their existence is known, their harmful effects on the eye can be easily guarded against.

The electric arc between carbon and iron, and iron and iron, is one of the most prolific generators of these harmful rays, and operators on arc welding must necessarily be extremely careful in the employment of protective screens. Indeed, it may be stated that electric welding calls for eye-sight protection against intense heat rays, glare, flickering, and ultra-violet rays. Notwithstanding this fact, however, complete immunity from bad effects to the eyes of operators can be assured by the proper use of protective lenses. The masks that are commonly used by operators not only are necessary for the protection of the face and neck from direct dangerous radiations but for the protection of the eyes from reflected ultra-violet rays; these rays together with heat rays can be reflected from a surface in the same way as visible light so that complete protection can only be assured by cutting off all light from the eye excepting that which passes through the lens.

For the same reason arc welding should not be carried on in an open shop or even behind screens closed only at the sides. The reflection of the vivid and flickering flashes from the walls and ceiling may easily affect the eyes of other operators who are not engaged in welding, and are, therefore, unprovided with any protective device.

The light from mercury-arc lamps is also rich in ultra-violet rays, but when these lamps are made of glass the rays are absorbed, thus rendering the light harmless excepting for the glare. When made of clear quartz, however, they should never be used excepting when thoroughly screened by suitable glass shades, or very dangerous eye trouble will be sure to ensue since clear quartz is transparent to ultra-violet rays. Spectacles or eye glasses made with so-called pebble or crystal lenses, (*i. e.*, natural clear quartz), therefore, afford no protection to the wearer; but the rays cannot pass through the ordinary lenses of plain clear glass.

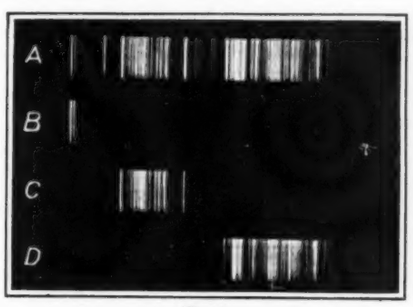

Fig. 1

(A) Spectrum of Iron; (B) Spectrum through Ruby Glass; (C) Spectrum through Green Glass; (D) Spectrum through Blue Glass.

Ultra-violet rays produce the effect known as "fluorescence" in certain chemical substances. When these substances are seen by a mixture of visible and ultra-violet light, such as that emitted from the iron arc, their apparent color is changed. Thus, soda salicylate in tablet form or in powder changes its color from pure white to a bright blue while it is illuminated by the mixture of rays, unless the visible light is so strong that it overpowers the fluorescent color. A high-tension disruptive discharge of electricity between iron points is an excellent source of ultra-violet rays for producing fluorescent effects, because it emits an excess of ultra-violet rays as compared with its visible light. A pebble or crystal lens can be readily distinguished from one of plain glass by this light, for if the lens is interposed between the iron spark discharge and a fluorescent substance, such as soda salicylate, the blue color will immediately vanish and the salicylate will assume its natural white; but if the lens is made of quartz, the blue fluorescence will remain unchanged.

There are numerous substances that show different fluorescent colors under the influence of ultra-violet light, but soda salicylate is mentioned here because it can be procured at any drug store, whereas many of the other substances thus affected may be more or less difficult to obtain.

Fig. 1 shows the full spectrum of the visible light emitted by a disruptive iron spark discharge and also the absorption effects of various colored glasses when interposed between the spark and the photographic plate on which the spectrum is recorded.

It may be stated that the apparatus for producing ultra-violet rays as described and illustrated in the *General Electric Review*, April, 1916, p. 317, is especially suitable for testing spectacles or eye glasses to ascertain if the lenses are made of natural quartz or ordinary optical glass.

Earthquake Weather

The term "earthquake weather" is often encountered in California, but meteorological text-books do not mention it. Those who use the term are unanimous in referring to a condition of hot and calm weather, without much cloud, but usually with more or less haze. The condition is not greatly unlike that which usually precedes a summer afternoon thunderstorm in the Middle West. As the term "earthquake weather" has not yet become commonplace in scientific literature it would be interesting to learn what seismologists think about the matter.—From a paper by Andrew H. Palmer in *The Bulletin of the Seismological Society of America.*

Cannel Coal in the United States*

Its Origin, Composition, Mode of Occurrence and Uses

By G. H. Ashley

CANNEL coal is mentioned incidentally in a great many publications but in most of them only as a matter of curiosity, and even if it may be mentioned in the text of a book it has seldom been noted in the index, so that in reviewing the literature it has been necessary to go over many books page by page. Most of the longer memoranda on the cannel coal of this country were made during or just after the period of great interest in cannel coal, between 1855 and 1860, or just before the discovery of our great reservoirs of petroleum. At that time it was the principal source of our oil supply, nearly 60 distilleries being in operation in the United States in 1860. The discovery of rock oil naturally knocked the bottom out of the "coal-oil" industry, but the new growing demand for hydrocarbons may lead to a revival of the mining of cannel coal. In this connection it is desirable to call attention to a fact brought out elsewhere in this report—that all so-called cannel coals are not equally valuable for producing oil and gas, notwithstanding the prices at which they may now be selling for use in grates; two cannel coals may be of equal value for use in grates and may therefore now bring the same price, but one may have twice the value of the other for distillation for oil or gas.

Cannel coal is a massive, noncaking, tough, clean, block coal of fine, even, compact grain, dull luster, commonly conchoidal cross fracture, having a typical low fuel ratio, a high percentage of hydrogen, easy ignition, long yellow flame, black to brown greasy streak, and moderate ash, pulverulent in burning. It is essentially a rock derived by solidification and partial distillation or oxidation of water-laid deposits consisting of or containing large quantities of plant spores and pollen grains and more or less comminuted remains of low orders of water plants and animals.

In such a deposit of decaying spore and pollen material, containing both vegetal and animal débris to which Potonié[1] has given the name "sapropel," there may be admixed greater or less quantities of mud or of woody or peaty material. The high volatile content and high hydrogen of cannel coal appears to be derived from the spore and pollen and waxy material and, to an unknown extent, from animal remains. The greater the admixture of woody or peaty material derived from the usually adjoining peat marshes, the more closely the cannel coal resembles chemically the associated bituminous coals and the smaller the proportionate yield of oil by distillation. Cannel coals in common with other coals also differ in character and value because of changes they undergo, first by decomposition and later by physical and chemical changes due to pressure and heat, especially to pressure due to the weight of superimposed rocks and to the horizontal thrusts that have locally folded and otherwise disturbed the earth's crust. The effect of these forces has been somewhat similar to that of slow distillation, driving off first the moisture, then the higher hydrocarbons, then the heavier hydrocarbons, and ultimately, if continued, nearly or quite all of the volatile hydrocarbons. It is evident that the deposit will be of greatest value as a source of oil at that point where the largest percentage of water and the smallest percentage of volatile hydrocarbons have been driven off. Such coal may be termed typical cannel. Coals which have not reached that rank may be called subcannels, and those which have much passed that point and have thus lost all their peculiar qualities may be called canneloid coals.

Typical cannel coal is distinguished from bituminous coal by the following contrasting features:

Bituminous coal	*Cannel coal*
1. Laminated.	1. Massive.
2. Bright and dull bands.	2. Uniform velvety or satiny luster.
3. Prismatic fracture.	3. Conchoidal fracture.
4. Jointing imperfect.	4. Jointing regular and striking.
5. More or less friable.	5. Tough and elastic.
6. Disintegrates by weathering.	6. Weathers slowly; used for foundation of barns, etc.
7. Soils the hands.	7. Does not soil the hands.
8. Percentage of fixed carbon higher than that of volatile matter.	8. Percentage of fixed carbon typically lower than that of volatile matter (except in lean cannels).
9. Derived from woody or peaty deposits grown in place.	9. Derived mainly from spores, pollen, etc., brought in by wind and water.
10. Basins commonly extensive.	10. Basins rather small; many are narrow channels.
11. Commonly yields on distillation less than 10,000 cubic feet of gas to the ton.	11. Commonly yields on distillation more than 10,000 cubic feet of gas to the ton.
12. Candlepower of gas commonly less than 17.	12. Candlepower of gas commonly more than 20.
13. Commonly cakes in burning.	13. Does not cake in burning.
14. Coke usually strong.	14. Coke pulverulent.
15. Yield of oil on distillation commonly less than one barrel to the ton.	15. Yield of oil on distillation from one to more than two barrels to the ton.
16. Less than 6 per cent hydrogen.	16. More than 6 per cent hydrogen.
17. Ignites with difficulty.	17. Ignites readily.
18. Streak commonly black.	18. Streak commonly brown.

CLASSIFICATION

The subcannel coals may be divided into two ranks, corresponding to lignite and subbituminous coals, which may be distinguished as brown and black subcannels.

Cannels may be divided into two or three ranks—boghead cannels having a fuel ratio of 0.5 or less, named from their resemblance to the famous "boghead" of Scotland; cannels (including boghead), having a fuel ratio of 1 or less; and semicannels, having a fuel ratio of more than 1. A fuel ratio of 1 is a convenient point at which to draw the line between the typical and the lean cannels, but further research may show that it should be drawn a little higher or a little lower. This high fuel ratio may be due to dynamo-chemical changes, which decrease the percentage of volatile hydrocarbons, or to admixture of peaty elements in the original deposits, or to both.

If the fuel ratio of a cannel coal is more than 1 and the pure coal of the associated bituminous coal contains less than 65 per cent fixed carbon, the high fuel ratio is probably due to the presence of peaty elements in the original deposits. As such coals stand between bituminous and cannel coal they are properly called semicannels. On the other hand, low-volatile cannels that are associated with high-carbon bituminous coals may have been originally either non-peaty cannels or peat cannels. A detailed investigation of the constitution of these coals doubtless reveals significant differences between these types and future distillation practice may disclose economic differences—in the yield of certain hydrocarbons, for instance. At present, however, for practical purposes they may all be considered lean cannels or semicannels.

Cannels that are associated with semibituminous, semianthracite, and anthracite coals and that have so far lost any peculiar advantage over the coals with which they are associated as not to be separated in mining, marketing, or use may be classified, according to their nature, as canneloid, semibituminous, semianthracite, or anthracite.

Cannel coals may therefore be classified, largely in genetic sequence, as follows:

1. Subcannel coal:
   - (*a*) Brown subcannel, of brown coal or lignite rank.
   - (*b*) Black subcannel, of subbituminous rank.
2. Cannel coal of bituminous rank:
   - (*a*) Boghead cannel (fuel ratio less than 0.5).
   - (*b*) Cannel, typical (fuel ratio less than 1).
   - (*c*) Lean cannels or semicannels (fuel ratio more than 1).
3. Canneloid, semibituminous, semianthracite, or anthracite coal.

The grade of a cannel coal varies with the amount of ash or other impurity it contains. The bodies of water in which the cannels were laid down were at some places subject to inflows of mud, so that the deposit at such places might contain from less than 5 per cent to 100 per cent of ash, or might range from a pure cannel coal to a non-bituminous shale. The line between a coal and a shale has never been sharply drawn, but the suggestion is here made that material which, when burned, breaks down and yields an ash that goes through the grate bars and shows no tendency to maintain its original shape is a coal, and that material which on burning yields an ash that tends to maintain its original shape is a shale. The exact percentage of ash that should distinguish a coal from a shale can not yet be given, but until more exact figures are available it is suggested that material that yields less than 33 per cent of ash be considered a coal.

High ash, though it reduces the grade of a cannel coal, does not necessarily mean that the coal will not yield a large proportion of hydrocarbons, for many original deposits were not laid down in peat bogs and so contain little woody material. Such deposits may therefore yield coal that is rich in oil-making elements even though they may be high in ash. Thus an analysis of Scotch boghead shows nearly 20 per cent of ash, but more than 70 per cent of volatile hydrocarbons and about 10 per cent of fixed carbon. Some of the boghead shales of this country will yield from a barrel to more than two barrels of crude oil per ton of rock. Thus, as David White has suggested, such coals may be arranged in a series ranging from cannels through boghead cannels and cannel bogheads to bogheads.

The Scotch boghead and other bituminous shales have long been distilled for oil, and such shales are abundant in this country. Nearly all the coals described in this report are cannel coals, but a few analyses of canneloid coals are given for comparison, and a typical brown subcannel from Arkansas, a black subcannel from Utah, and a subcannel from Texas are briefly described.

COMPOSITION

The composition of cannel coal is determined in three ways—by microscopic examination, by dissolving out its component parts by pyridine or other solvent, and by destructive distillation or analysis.

The fundamental differences between typical cannel coal and typical bituminous coal appear to result from the fact that they were deposited under different conditions and consequently were composed of different original substances, which formed different decomposition products. It is now very generally agreed that most coal is transformed peat. Cannel coal, however, appears to have been formed in part from decayed spores or pollen and other floating remains of plants, as well as of remains of minute or slow-moving animals, such as are commonly found today in the bottoms of lakes. In a peat bog decay is only partial, but in the more open waters of lakes or lagoons, whether surrounded by bogs or not, decomposition is likely to affect almost the whole mass of organic matter that settles to the bottom except the spore cases, or outer coverings of the spores, which are naturally very resistant, and some few other end products. These spores appear to have been mainly those of ferns and related plants, which were abundant, during the Carboniferous period as well as later, and most of which were much larger and on the whole far more abundant than those of today. Associated with material of this type in some deposits of cannel coal, according to Newberry,[2] there are abundant remains of fish and other free-swimming animals. Many of the spore cases, though flattened, are well preserved; others are broken down into a pulp or ooze. According to Von Gümbel, Bertrand, Renault, and Thiessen[3] cannel coal, when viewed under the miscroscope in thin sections, consists mainly of spore cases in different stages of decay, with which are associated a very minor proportion of other bodies, like particles of resin, resistant seed coats, fragments of cuticle, and waxy bodies. In view of the difference in resistance to decay between the spore cases and the watergrowing plants, such as algae, it may be doubted whether the presence of spore cases only should be taken as proof that spores have been the main source of the carbonaceous material. Associated with this pure coal matter is a greater or less proportion (10 to almost 100 per cent) of clay or sand, which forms the ash. As the proportion of shaly matter increases the coal changes to a bituminous or oil shale and locally to a nonbituminous shale.

COMPARISON WITH OTHER COALS

Most cannel coals may be distinguished from other bituminous coals by the large proportion of high-candlepower volatile matter that is driven off from them at high temperatures or the large proportion of oil that is driven off at low temperatures and by the high percentage of hydrogen they yield on ultimate analysis. Doubtless more fundamental chemical differences would be found were it possible to determine exactly the chemical combinations existing in the coals, but no method of doing this completely has yet been devised. An ordinary analysis of coal may show either the proportions of the elements it contains or the products that may be obtained by heating the coal to a certain high temperature—the products differing according to the temperature and pressure applied.

By the usual methods of analysis, bituminous coals

*Abstracts from Bulletin 659 of the U. S. Geological Survey, by G. H. Ashley.

[1] Potonié, Henry, Die Entstehung der Steinkohle, 5th ed., p. 3, 1910.

[2] Newberry, J. S., On the mode of formation of cannel coal: *Am. Jour. Sci.*, 2d Ser., Vol. 23, p. 214, 1857.

[3] White, David, and Thiessen, Reinhardt, The origin of coal: *Bur. Mines Bull.* 38, pp. 248 et seq., 1913.

will yield from 45 to 75 per cent of fixed carbon and from 20 to 45 per cent of volatile matter. The fuel ratio of such coals—that is, the ratio of the fixed carbon to the volatile matter—will range from one or a little over for the coals of the Mississippi Valley to two or more for the coals in the eastern Appalachian field.

In contrast with these figures, typical cannel coals contain from 25 to 45 per cent fixed carbon and from 45 to 70 per cent volatile matter, or gas, the fuel ratio ranging from one down to 0.5 or less.

David White[4] has recently called attention to the fact that petroleum does not occur in rocks near a bed of coal containing 65 per cent or more of fixed carbon, having apparently been driven off by heat and pressure. The fact that the semicannel coals from Armstrong County lie east of the oil field of Pennsylvania indicates that the action which restricted the Pennsylvania oil field also made semicannel of cannel coals. As these semibituminous and semianthracite canneloid coals from Tioga County eastward have so little in common with the true cannels in commercial use, they are not further considered in this report.

The semicannel coals of the Mississippi Valley States, such as those in Kentucky, lie so close to cannel coals high in volatile matter as to lead to the belief that the two may have had a very different origin. Thus, at Cannel City, Ky., in a single hill, there are two coal beds, one a typical cannel containing 52 per cent of volatile matter and 36 per cent of fixed carbon and the other, which is mined mainly as cannel, containing only 40 per cent of volatile matter and 50 per cent of fixed carbon. The cause of this difference has not yet been determined.

The igniting point of cannel coal is given by Lewes[5] as 668° F. or 370° C_2, as compared with 842° F or 430° C. for lignite, and 870° F. or 477° C. for Welsh steam coal. As is well known, the name cannel comes from candle, the early name of the coal, employed because of the readiness with which a splinter of it ignites and burns "like a candle."

ORIGIN

More than fifty years ago Newberry[6] recognized the fact that cannel coals have the nature of water-laid deposits. According to White and Thiessen[7] the microscopic study of cannel coals shows that they include fern spores, water weeds, algae, and other material that naturally accumulates in the open water of swamps. The remains of certain water animals—fish, mollusks, amphibians, and crustaceans—are in places associated in abundance with cannel coals. Finally, in many places cannel coal grades over into bituminous shale or ordinary shale. In a cut on the Indiana Southern Railroad near Burn City, Daviess County, Ind., a bed of cannel coal, a foot or two thick, grades upward into coal which is similar in appearance, but which, on burning, leaves about half its original bulk as ash, and still higher into material which, though it resembles cannel, is reported by those who have tested it in a stove to leave a volume of ash greater than that of the coal put in. Above that bed the black color gradually turns to gray, and at the top there is only an ordinary gray clay shale. In some areas cannel coal grades into shale horizontally.

The close relation of cannel to shale is also seen in the high ash content of many cannels, due to the washing in of mud during the formation of the coal. Mud washed into an open water basin tends to accumulate most abundantly at the point of entrance, and cannel forming in such a basin may be quite free of ash in one part and be high in ash in another part.

That the material of cannel coal has been formed by the settling of floating material and not from plants grown in place is further indicated by the fact that cannel coal, unlike bituminous coal, which is generally underlain by a bed of clay containing the roots of plants, in many if not in most places rests on rocks other than clay.

Again, although bituminous coal usually shows distinct banding, supposed to be due to changing surface conditions in the coal marsh, cannel coal is homogeneous, as if the conditions remained constant during the whole period of its deposition.

Furthermore, Newberry[8] has called attention to the fact that in lagoons of open water found near modern peat marshes a fine carbonaceous mud accumulates that, when properly dried resembles cannel coal in appearance and in many properties.

Many theories have been advanced to account in detail for the formation of cannel coal. According to the theory here stated, it was formed at the bottom of open-water basins or small channels, most of them in coal-forming swamps (as indicated by the almost universal association of cannel with bituminous coal), by a steady accumulation of plant spores, pollen, resins, waxes, and other carbonaceous material. The source of the large percentage of volatile hydrocarbons, especially ethylene gas, which it yields on distillation, remains to be determined. Possibly these hydrocarbons were formed by the decomposition of the inner parts of the spores, having been held in temporary storage within the tough fine-grained spore cases. No study has been made, to the writer's knowledge, of this particular question, though distillation tests have been made on spore dust mixed with fuller's earth. One test reported by Ellis[9] the conditions of which are not known, yielded 23.8 gallons of crude oil (specific gravity, 0.93) and 3.3 pounds of sulphate of ammonia per ton.

MODE OF OCCURRENCE

Too much stress cannot be put on the fact that cannel coal occurs in very small basins. Thousands of dollars have been wasted in expensive preliminary equipment for mining deposits of cannel coal which proved to contain less than a year's supply. Long railroad spurs, one as much as 12 miles in length, have been built and expensive plants have been erected on the favorable showing presented by a single opening. A cannel-coal basin should therefore, be prospected as thoroughly as a gold lode. It should be tested not by drilling every 10 acres but by drilling every acre. Where the coal lies high in the hills it may be sufficiently prospected by drillings or openings 100 yards apart. The fact that thick cannel is found at two points a quarter of a mile apart is no guaranty that it is thick between those points.

USES

Heating.—High-grade cannel coal is adapted to most of the common uses of other bituminous coals except the making of coke. As it burns freely, it was used in the early days in the manufacture of iron. It is an ideal grate fuel and has long been used for that purpose, for it mines out in blocks, is clean to handle, and gives a bright, cheerful blaze, resembling that of a wood fire. It differs from wood, however, in containing only a small percentage of moisture, for wood is 50 per cent water, so that it does not require constant replenishing and makes a fire that can be left overnight. Where grates are the principal means of heating houses the special advantage of cannel coal are readily apparent.

Owing to the large percentage of gas it contains cannel coal ignites quickly and is useful where a hot fire is needed in a hurry. It has long been a satisfactory fuel for fire engines and during recent years has found one of its principal markets in city fire departments.

Gas Making.—For many years cannel coal was most largely used for enriching coal gas. Cannel coal does not make a good coke and is not so cheap as other bituminous coals, or its large content of gas of high candlepower would undoubtedly cause it to be used for the manufacture of coal gas to the exclusion of all other coals. The so-called "gas coals" contain 30 to 40 per cent of volatile matter, whereas the better grade of cannel coal contains 50 to 60 per cent, and its gas has double the illuminating power of that in the gas coals. Thus Hocking Valley coal will yield about 8,000 cubic feet of 14-candlepower gas and Westmoreland coal about 10,000 feet of 15 to 16 candlepower gas per ton of coal. By contrast, Flint Ridge, Ohio, cannel will yield 9,000 feet of 23-candlepower gas per ton; Kanawha, W. Va., cannel will yield 10,000 feet of 18 to 19 candlepower; richer cannels will yield from 13,000 to 15,000 cubic feet of 30 to 40 or even 50 candlepower; and according to McMillin[10] some of the special bituminous substances will yield as high as 131 candlepower.

As most cities require gas of a higher candlepower than could be obtained from bituminous gas coals alone, it has been necessary to enrich the product by adding to it some gas of higher candlepower, and for many years cannel coal found its principal market for this purpose. Later, cheaper methods, especially the addition or substitution of oil-enriched water gas, were widely adopted, and today little or no cannel coal is used for this purpose.

Future demand may again lead to the distillation of cannel coal at high temperatures in order to obtain certain products or by-products. For that reason, as well as for the purpose of showing its behavior when so treated and the compounds it yields, the following data have been assembled:

The percentage of "volatile combustible matter" shown by analysis is not a true index of the amount of fixed gas that may be obtained in practice. Thus, by a series of tests, Wormley[11] obtained (among other results) from coals yielding 27.7, 30.7, 37.2, 38.0, and 39.2 per cent of volatile matter on analysis, 3.32, 3.51, 3.12, 3.65, and 3.35 cubic feet, respectively, of fixed gas per pound of coal. The temperature at which gas is made also affects greatly both the quantity and quality of the gas—the higher the temperature the greater the quantity of gas and the lower the candlepower. Experiment has shown a marked difference in the composition of gas derived from cannel coal and that derived from the bituminous gas coals, as is clearly indicated by the difference in the candlepower of the two gases. This difference consists principally in the smaller percentage of uncombined hydrogen and the larger percentage of olefines, especially ethylene, in cannel gas.

It is due, no doubt, to the abundance of ethylene that cannel coal has so high an illuminating value. Though unable to find, at the time of writing, analyses of the volatile matter from cannel coal, the writer recalls analyses in which the percentage of ethylene, for example, was several times as high as in gas from bituminous coal reported in the same table. Ethylene (C_2H_4) is what is called an unsaturated hydrocarbon—that is, one having the formula $C_n H_{2n}$ rather than the formula C_nH_{2n+2}. As a result, in burning, it first breaks up into methane, or marsh gas (CH_4), setting free carbon, which is next heated to incandescence, yielding the light, and then burned to CO_2.

Coke Making.—It is well known that cannel coal will not make good coke. It belongs to the group of free-burning coals which do not intumesce or run together into a cake, and the coke made from it is, as a rule, pulverulent and soft, that made from some beds crumbling at once to powder. It would seem to be feasible to use this coke in the production of water gas or producer gas or for burning under furnaces as dust, but not in metallurgy nor for stove use.

Oil Making.—The use of cannel coal of most interest, both in the past and in the future, however, is in the production of oil and other chemical by-products. It was this use that led to its widespread mining from 1855 to 1859, when the discovery of petroleum opened the way to its displacement, and it is this use that is apparently again calling attention to it, the oil now being demanded for conversion into the lighter hydrocarbons (especially gasoline) for use in portable motors and the by-product chemicals for the enlarging chemical industry of the country.

The use of coal for the production of oil is not recent, it having been employed for the purpose as early as 1760. In Lewis's *Materia Medica*, published in that year, mention is made of oils distilled from black bituminous shales for medical purposes. Even earlier than that, in 1694, patents were issued, according to Gesner,[12] to Eele, Hancock and Portlock for making "pitch, tar and oyle out of a kind of stone." In 1781 the Earl of Dundonald distilled oil from coal, and others distilled oils and tars from bituminous schists, so that at an early date these oils, somewhat purified, were used for burning in lamps and for lubricating machinery.

Abraham Gesner claims to have been the first to manufacture oil from coal in the United States, and in 1846 exhibited the use of his oil in lamps. His patents, known as the "kerosene patents," granted nine years later, were sold to the North American Kerosene Gaslight Company, which proceeded to make and sell "kerosene oil," as it was called. This early oil was not so highly refined as kerosene is today, and a disagreeable odor in burning kept down its sale. It came into common use about 1854. Modern methods of distilling cannel coal would doubtless follow in the main the methods now used in Scotland and Germany in the distillation of oil shale, described by Baskerville[13] and by Ells.[14] Baskerville has also described the methods in use in the United States when cannel coals were formerly distilled for oil.

Distillation for By-Products.—The renewed interest in cannel coal is largely based on its supposed value as a source of what were formerly considered by-products in the manufacture of artificial gas, but which at present have become of primary importance. The figures already given indicate clearly that certain lean or semi-cannel coals, though suitable for certain uses (as in household grates), have no advantage over bituminous coals in the production of gas or oil. The figures also show, however, that the higher-grade cannel coals yield a variable but always larger percentage of the coal gas,

[4]White, David, Some relations in origin between coal and petroleum: *Washington Acad. Sci. Jour.*, Vol. 5, p. 212, 1915.

[5]Lewes, V. B., The carbonization of coal, etc., p. 22, 1912.

[6]Newberry, J. S., On the mode of formation of cannel coal: *Am. Jour. Sci.*, 2d Ser., Vol. 23, p. 212. 1857.

[7]White, David, and Thiessen, Reinhardt, The origin of coal: *Bur. Mines Bull.* 38, 1913.

[8]Newberry, J. S., Ohio Geol. Survey Rept., Vol. 2, pt. 1, p. 125, 1874.

[9]Ells, R. W., Joint report on the bituminous or oil shales of New Brunswick; also on the oil-shale industry of Scotland; pt. 2, Geology, p. 69, Canada Dept. Minew, Mines Branch, 1909.

[10]McMillin, Emerson, The gas coals of Ohio: Ohio Geol. Survey Rept., Vol. 5, Economic geology, pp. 722-749, 1884.

[11]Wormley, T. G., Report of chemical department: Ohio Geol. Survey Rept. Progress for 1870, pt. 5, p. 410, 1871.

[12]Gesner, Abraham, Practical treatise on coal, petroleum, and other distilled oils, 2d ed., p. 8, New York, Baillière Bros., 1865.

[13]Baskerville, Charles, Economic possibilities of American oil shales: *Eng. and Min. Jour.*, Vol. 88, pp. 152-153, 1909.

[14]Ells, R. W., Joint report on the bituminous or oil-shales of New Brunswick; also on the oil-shales industry of Scotland; part 1, Economics, pp. 13-14, Canada Dept. Mines, Mines Branch, 1913.

coal oil, and ammoniacal liquor, and it is hoped that some method may be found for obtaining benzol and its derivatives from these by hydrogenation.

Experiments by the Bureau of Mines showed, according to Dr. G. B. Taylor, not only that cannel coal differs from other bituminous coals in the larger volumes of tar or oil and gas it yields, but that because of the low temperature at which the liquid products come off they consist mainly of saturated and unsaturated paraffin hydrocarbons, together with tar acids and but little of the valuable benzene and toluene. The low-temperature oils are difficult to refine and as yet have found no ready market. Their possible uses are as flotation oil and as sources of gasoline and creosote. The difficulty in refining for gasoline comes in removing the unsaturated bodies, notably paraffins of the ethylene series. Hydrogenation may in the future obviate this difficulty. Many studies are yet needed of tar and gas derived from cannel coal at high temperature and of the results of "cracking" or other subsequent treatment of the low-temperature distillation products.[15]

Synchronous Signalling at Sea

THE advantages which would follow the employment of synchronous signalling between ships and shore stations and lightships, as well as between ships at sea, were dealt with in two lectures delivered before the Royal Institution by Prof. J. Joly, who is one of the Irish Lights Commissioners, and who has devoted special attention to this subject.

The lecturer said that the special difficulties of determining the position of a ship are fully realized only by those who have endeavored to make a land-fall or pick up a lightship in stormy weather, or in the obscurity of fog. Sailing directions which are still followed indicate that there is no help for a sailor under such conditions save fog signals and the use of the lead, and the latter is assumed to be the only safe guide under conditions of fog when approaching land. That does not imply the general worthlessness of aerial sound signals, and indeed it is not likely that any proposal for their disuse would find favor with navigators. The lecturer's purpose was to consider the employment of additional aids to navigation whereby the sailor can escape the dangers arising from aerial signals, and is supplied with other signals at once more reliable, received at greater distances and giving information beyond the power of aerial fog signals to convey.

SIGNALS IN DIFFERENT MEDIA

There are obvious objections to the use of sound signals passing through the atmosphere, the most serious being the strange, but not very common, phenomena of silent areas, the most feasible explanation of which is that the sound wave follows a sinuous path, rising from and then sinking to the level of the sea, a fact which introduces a source of error in any calculation of distance based on the velocity of sound in air. Flashlight signals have the disadvantage of being invisible in foggy weather, and only under certain conditions is the combination of synchronized light and sound signalling of real value. It ought, however, to be developed to assist the navigation of small craft. The best combination would be a synchronized light flash and bell stroke; and an automatic bell buoys, as well as buoys which show an occulting light, are somewhat common round the British coast, such a system would be easy to arrange. If the intervals between the light flashes could be fixed to represent a predetermined distance, as compared with the reception of a simultaneously emitted aerial sound signal, it would only be necessary to count the number of flashes before the bell is heard to determine the distance in cables and nautical miles. The initial cost of such a system would be quite small, and the upkeep trifling, and it would be of great advantage to small craft which were debarred from the use of wireless or submarine signalling. In the existing system of coast signals there is, however, no coordination, and under the present method the navigation contains only a bearing indication; whereas if the signals were synchronized they would enable a determination of distance to be made with sufficient accuracy to enable the navigator to fix his position.

The lecturer described his proposal as being to employ a system of signals propagated in different media, but timed to start at the same instant and depending for efficiency on different rates of propagation, and at the same time to eliminate the effect of weather conditions and the uncertainty of aerial signals by the use of wireless in association with submarine signalling. Sound travels through water at a rate of 4,800 feet per second, so that the submarine bell stroke lags behind the wireless dot signal by 1.2 seconds for each nautical mile of distance traversed. After a great deal of experimental work the present type of bronze submarine bell weighing 220 pounds has been evolved and is doing duty in all parts of the world. The striking mechanism is usually operated pneumatically, but in some cases, of which the bell placed off the Stack Lighthouse at Holyhead is an example, electrical methods are employed. The listening devices on board ship in their latest form are quite simple. The United States Government has installed synchronous signalling, combining the submarine bell and the wireless dot, on the Fire Island Light-ship off New York Harbor, and this, the first practical commercial station of its kind, has given proof that this method of signalling is more free than earlier systems from liability to failure.

FESSENDEN OSCILLATOR AND RADIOPHONE

The use of the Fessenden oscillator has enabled the range of audibility of sound signalling through water to be extended up to 30 miles, and a further advantage is that the Morse code can be employed and that signals can be received and transmitted by one apparatus. There is also the possibility of determining the depth of water beneath moving vessels by echo from the bed of the sea, and of locating icebergs by sound reflection from the submerged part of the berg. A probable development is the transmission of speech, if only over short distances. Wireless telephony has now been pressed into service, and the installation of the radiophone at Point Judith on the western approach to Narragansett Bay, which is the first of its kind, has furnished proof that wireless telephony may play a great part in future methods of signalling at sea. This station communicates its name to vessels equipped with receiving apparatus over a considerable distance, and has a special danger signal for ships coming too close to the shore. This method of signalling, in conjunction with the employment of the wireless compass, enables the navigator to obtain the bearing of the signals as well as the name of the station, but it is necessary to employ synchronous signaling for a calculation of distance.

PREVENTION OF COLLISION

The existing rules for preventing collision at sea have been in service for more than a generation. They have given excellent results within the obvious limits of their application. In thick weather, however, reliance has still to be placed on the crude methods of whistling and listening, and Professor Joly thinks that the moment is opportune for a reconsideration of the whole question in the light of modern development. He does not propose that the existing rules should be abrogated, but that they should be supplemented by synchronous, wireless and submarine sound signals which would enable the distance between vessels to be determined certainly to within half but probably to within a quarter of a nautical mile. Either the submarine bell or the oscillator can be employed, and the system would, it was pointed out, enable the bearing of the ships as well as distances apart to be ascertained, and furnished data from which the collision risk could be accurately determined. In this connection, Professor Joly proposes the use of an instrument which he terms the collision predictor, by means of which what may be called the danger bearing and the danger rate of approach can be compared with the actual bearing and the actual rate of approach even in thick fog. This would necessitate a continuous watch in the wireless room on all ships during thick weather.

It is believed that additional safeguards will be obtained from the use of wireless telephony. It is indeed possible even today for a vessel at sea to call her own name at regular intervals and to give at longer intervals her course and speed. If at the same time such a vessel sent out submarine signals so that other ships could ascertain her distance the ship would be surrounded by a zone through which could be transmitted by unmistakable signals information as to her position to all other vessels entering that zone, and thus enable high speeds to be maintained in ocean service without risk of accidents arising from collision.—Engineering Supplement of the *London Times*.

T. N. T. Poisoning

A REPORT containing the results of Dr. Benjamin Moore's researches on "The Causation and Prevention of Trinitrotoluene Poisoning" has just been issued by the Medical Research Committee. It is shown that the only important avenue of entrance into the body is through the skin. The amount taken in as vapor or as dust is innocuous. The first noticeable indications of poisoning are those due to deficient oxygen supply, especially blueness of the skin and lips. This results from the action of the poison in decreasing the capacity of hæmoglobin to take up oxygen, a well-known effect on the respiratory process produced by nitro- and aminio-benzene derivatives in general. Trinitrotoluene is said to convert hæmoglobin into its N O derivative, together with met-hæmoglobin. Various results follow from the deficiency of oxygen supply to the organs, but whether the degeneration of the liver and the consequent jaundice are secondary, as Dr. Moore holds, or whether the poison acts directly on the liver cells, is at present a matter of dispute. The same may be said for the anæmia. But the practical point is that the cynaosis is the sign to be looked for. Individuals differ in the property of their skins to absorb the poison, and it is recommended that all those showing susceptibility should be rigorously excluded from the work. A further preventive is covering the arms and hands with a casein varnish. Gloves are useless. The poison is reduced in the body, probably by the liver, to the hydroxylamino-derivative, and eliminated in the urine, conjugated with glucuronic acid. It is important, therefore, that the diet should include substances which afford a supply of this acid—namely, fresh vegetables and fruit.—*Nature*.

[15] Rittman, W. F., The Rittman gasoline process: *Nat. Petroleum News*, Vol. 7, pp. 2-4, 1915. Since the above was written the Bureau of Mines has issued a bulletin by Rittman, Dutton, and Dean (Bull. 114), describing in detail the Rittman and other processes for the cracking of oils and the methods of producing the aromatic hydrocarbons used in making explosives, including a very complete bibliography on these and related subjects.

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